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Safeguarding youth from agricultural injury and illness: International experiences

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Safeguarding youth from agricultural injury and illness: International experiences

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Editorial: Safeguarding youth from agricultural injury and illness: international experiences

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Editorial on the Research Topic
Safeguarding youth from agricultural injury and illness: international experiences

Worldwide, agriculture is among the most dangerous industries and one of the few that involves children (<18 years-of-age) in the worksite as laborers or bystanders (1). Children are exposed to an array of agriculture-related hazards whether working or merely being present in the farm environment. From a public health and child advocacy perspective, safeguarding these young people from preventable disease and injury is important for many reasons. The negative impacts of a childhood agricultural disease or injury range from permanent disabilities, death, family disruptions, and economic hardships including the potential loss of a sustainable family farm enterprise (2). At the same time, growing up in an agricultural setting can lead to independent, hardworking, successful adults, who gain a range of benefits, including skill development, family time together, improved immune response, and other protective health factors (3, 4).

Interest in agricultural occupational safety gained traction in the 1950s as awareness of the preponderance and preventability of fatal and non-fatal farm injuries grew, combined with increased industrialization and mechanization in agriculture, and the increasing science around occupational health and safety. However, despite the family farm model being the most prevalent structure in agriculture worldwide, it was not until the early 1990s that a growing interest in child safety on farms culminated in the first major symposium on childhood agricultural injury prevention. Convened in the United States, this symposium brought together a range of stakeholders, including researchers, educators, and advocates with different perspectives, and was key to launching a network of stakeholders around the goal of ensuring the safety of children on farms (5).

In 1997, the National Children's Center for Agricultural Health and Safety (NCCRAHS) (https://www.marshfieldresearch.org/nccrahs) was established with funding from the US National Institute for Occupational Safety and Health. To our knowledge, this US-based center is the only research and outreach center funded by a national government that is dedicated solely to agricultural health and safety of children. As NCCRAHS celebrates

its 25th anniversary, this special *Frontiers in Public Health* issue provides an opportunity to take stock of the childhood agricultural injury prevention scholarship globally and to reflect on opportunities to move forward. Ultimately, our goal with this Research Topic is to strengthen international collaborations to reduce the toll of preventable childhood farm injuries and illness.

In this Research Topic, we provide 28 papers that explore a wide spectrum of issues associated with safeguarding youth from agricultural injury and illness. These include two sets of papers: (1) solicited commentaries providing country-specific descriptions of the current situation of child and adolescent safety on farms and ranches, along with recommendations for the future; and (2) submitted papers, including original research, literature/policy/protocol reviews, brief research reports, and case studies. The editorial team's objectives were to: (1) reach out to international communities to identify organized efforts focused on childhood agricultural safety; (2) encourage individuals or groups to assess and document the status of efforts in their respective countries; (3) publish relevant commentaries, interventions, and research; and (4) synthesize findings and identify opportunities for collaborative strategies to address complex issues. As we embarked on this effort with *Frontiers in Public Health,* we reached out to as many different countries as possible, seeking diverse international perspectives on this topic. Through our collegial networks and internet searches, we made individual contacts with potential authors representing 31 different countries. It was disappointing to hear from colleagues in some countries such as France, Thailand, and Turkey that the topic of children and agricultural safety receives limited or no attention in their country, even when agriculture plays a key role in their economy. Overall, the submissions we received provide descriptive explanations of injury data (or lack thereof), major agents of agriculture-related injury, key concerns, and policy issues from eight countries across five continents.

These research findings, educational program descriptions, brief reports, and commentaries will take you on a journey across a wide range of issues. They include the most current data regarding child farm injuries and fatalities from publicly available news media (Weichelt et al.), youth's (un)willingness to work in the agricultural sector (Girdziute et al.), legal responses to traumatic injuries associated with child endangerment (Benny et al.), specific hazards such as all-terrain vehicles (Godler et al.; Brumby et al.), noting that there is a move to call them quadbikes, as it gives an impression that they can be driven anywhere (6), parents' perspectives of children working with livestock (Klataske et al.), to mental health of farm adolescents and their parents (Rudolphi and Berg). A unique aspect of this Research Topic is the international commentaries from eight countries (Maïga and Traoré; Grigioni; Lundqvist; Franklin; McNamara, Mohammadrezaei, Griffin; Pickett et al.; Shortall; Lee and Salzwedel), plus a report from Nigeria about the need for chemical safety training (Udoh and Gibbs), the challenges of agricultural safety in Africa's nation of Burkina Faso, who have recognized the rights of children but do not have specific laws around children working in agriculture (Maïga and Traoré), and/or the laws are not uniformly enforced, as in Argentina (Grigioni).

While the paucity of data was a reoccurring theme (Weichelt et al.; Grigioni; Franklin; Peden et al.), researchers from Australia (Adams et al.) have been working toward having a set of validated questions to help identify risks and effective prevention strategies on farms, while US researchers explore the use of existing surveillance systems to extract relevant data (VanWormer et al.). There are papers exploring new but also persistent areas such as youth's (un)willingness to work in the agricultural sector with authors from Lithuania, Finland, and Germany (Girdziute et al.), discussing the need to better describe positive opportunities and ensure training programs that link agriculture with nature and a love of animals (Klataske et al.), and the negative impact that peers sometimes have on farm injury risk perception of adolescents (Mohammadrezaei et al.). Another study revealed the invisibility of the lived realities of raising children on farms and lack of programming to help farm parents navigate the practical aspects of childcare despite childcare being a key farm safety strategy (Becot et al.). Two papers are about existing guidelines, Agricultural Youth Work Guidelines and Gear Up for Ag Health and Safety™ program, which are intended to provide options to safely incorporate children in farm work while they gain valuable work experiences (Brumby et al.; Swenson et al.). In contrast, youth's involvement in unsafe and extended hours of work is associated with failure of labor laws to protect them (Iannacci-Manasia). Another emerging issue is the increased number of public health emergencies, often associated with climate change, that impact youth in agriculture, and this concern is explored in a paper from Puerto Rico (Pagán-Santana et al.).

Benny et al. in their paper, describe the process for identifying legal responses to child endangerment on farms, comparable to non-farm cases, noting the purpose is not to induce punishment but to influence a culture of safety via a restorative justice process. This links to the work from Ireland, which demonstrates that children on farms are risk factors for adult workers (McNamara, Mohammadrezaei, Dillon, et al.). A survey in the US revealed there is a need to improve the dissemination of child farm safety resources (Salzwedel et al.), including the safety guidelines for youth agricultural work (Swenson et al.). It was also interesting to see new technologies being incorporated into farm safety education via augmented reality (Namkoong et al.) and the use of social media platforms such as Facebook for rural research participant recruitment (Burke et al.).

Several cross-cutting issues were noted in these papers. The lack of reliable, timely agricultural injury and fatality data is a common international theme for both adults and youth. The shortcomings of public policy and regulations seemed to be prevalent across all countries, and this was specifically highlighted in papers from the US (Lee and Salzwedel; Becot et al.; Iannacci-Manasia), Israel (Godler et al.), Ireland (McNamara, Mohammadrezaei, Griffin), Canada (Pickett et al.), and the United Kingdom (Shortall). Finally, the use of common terminology was encouraged. In countries where the discipline of injury prevention has matured, the word "accident" is avoided whenever possible, because the scientific discipline of injury prevention views fatal and non-fatal injuries as predictable and preventable. In the English language, the term "accident" implies a random, unavoidable event or act of God. The concept that injuries are not accidents is widely supported

in the literature (Salzwedel et al.). Thus, the editorial team gave instructions to authors to replace the term "accident" with other descriptive words such as injury event, incident, or details such as a crash or suffocation.

Safeguarding youth in agriculture is a complex issue, partly because of the complexity and diversity of farming, lax and inconsistent child labor regulations, international labor trafficking and servitude, economic hardships, limited childcare options, culture and tradition, a disconnect between knowledge of injury risks and actual safety practices, complex public policy frameworks, and changing developmental characteristics as children age. There is still a long way to go to reduce the toll of childhood farm injuries and illness. This *Frontiers* issue, with authors from 15 countries, reveals commonalities across borders and opportunities for collaboration. Perhaps, just as important, this Research Topic highlighted regions of the world where far more attention to children in agriculture is warranted. We hope child safety advocates in these locations can leverage the existing research and initiative to help secure the resources they need to address this topic. Policymakers also have a key role to play. Adequate and consistent funding is needed for effective research, outreach efforts, and community-based initiatives such as off-farm childcare programs. Public policy is also important to support evidence-based interventions such as minimum age for operating farm machinery on public roads or handling pesticides. We view our Research Topic of *Frontiers in Public Health: Safeguarding youth from agricultural injury and illness: international perspectives* as a call for greater international collaboration to ensure the safety of children and youth who live and/or work in agricultural settings across the globe.

Author contributions

BL: Conceptualization, Funding acquisition, Writing—original draft, Writing—review and editing. FB: Writing—review and editing. CBend: Writing—review and editing. CBenn: Writing—review and editing. PL: Writing—review and editing. AS: Writing—review and editing. BW: Writing—review and editing. RF: Writing—original draft, Writing—review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Youth's (Un)willingness to work in agriculture sector

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Work in agriculture is a significant area of research that highlights the problem of the integration of young people in the former, in particular, in the recent period. Work in agriculture is hard and not prestigious, and young people tend to leave rural areas in the search for alternative activities in urban areas. The study addresses the problem of how the youth should be integrated into agricultural workforce by focusing on identification of the reasons behind the (un)willingness to work in agriculture. The aim of the study is to assess the reasons behind the youth's (un)willingness of work in agriculture, using Lithuania as the case study. The data were collected by means of a questionnaire designed to investigate the perception and opinions toward work in agriculture. The Binary Logistic Regression was used to identify the factors affecting the youth's opinion about (un)willingness to work in agriculture. The study analyzed 430 young people 's responses to the questionnaires survey. The BLR has revealed that youth's unwillingness to work in agriculture is mostly affected by gender, area of residence and youths' beliefs that work in agriculture does not provide any opportunities for self-realization. In summary, this paper argues that the major motivation to work in agriculture is associated with having parents who are engaged in agricultural activities, love of animals and natural environment, and the availability of specialized training. The findings have confirmed the need to attract young people to work in agriculture. Its results are necessary for the scientific community, policy makers, farmers, and practitioners exploring the possibilities for integration of the youth into the agricultural workforce.

KEYWORDS

agriculture, perceptions, youth, willingness to work, work in agriculture

Introduction

Agriculture requires a growing workforce in order to meet the increasing demand for products. Unfortunately, employment has been declining dramatically in agriculture (to just 26.76% of the workforce in 2019 worldwide, according to the data by the World Bank[1]). Moreover, work in agriculture may also affect people's health and quality of social life. Agriculture is also the sector with the highest risk indexes (1), and can be described

[1]World Bank Open Data. Access: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?end=2019&most_recent_year_desc=false&start=1991&view=chart&year=2019.

as a specific business that is hazardous due to the chemicals used (2), requiring hard work, such as heavy physical activity, frequently unconventional working hours, etc. (3). Significant decisions that influence an individual and society's destinies place particular focus on the youth (4). In today's world, the youth have an important role as the future of food security and sustainable agriculture depend on them. Older farmers are generally considered to be used to conventional farming traditions and methods, and they will arguably be reluctant to adopt new technologies or innovations in their farms (5).

To address the above-mentioned problem, the EU have already been running several programmes to encourage young people to take up farming. For example, the European Common Agricultural Policy (CAP) programmes help farmers under 40 set up a business; member states offer young farmers an up to 25% bonus on top of their CAP subsidies, and advisory services and training schemes have been offered under the rural development programmes. Despite the above measures, the number of young farmers in the agriculture sector is still very small in the EU. Attraction of the youth to agriculture sector becomes more important now that the Green Deal guidelines have been announced. To attract young people to work in agriculture, it is necessary to make agriculture more dynamic and appealing compared to its present state. Moreover, young people need to be persuaded to view the sector more positively than they do now (6). The recent research also highlights that the youth remain an important component of the agricultural labor force (7, 8) in the aspiration to upgrade agricultural practices and utilize new technologies for greater agricultural growth. Youth involvement drives labor diversification trends from predominantly rural agricultural activities to more urban focused manufacturing and service sector activities.

Meanwhile, the youth tend to migrate from rural to urban areas (9, 10), and the agriculture sector is naturally facing the challenge of unemployment. Furthermore, high levels of unemployment lead young people out of rural areas (11). Youth unemployment in agriculture is one of the crucial questions related to development of agriculture sector, rural areas, communities, etc. (12, 13).

The "young farmer problem" articulates the issue of aging of farmer population (14). Farmers are getting older all around the world, and this aggravates the aging problem, which has become one of the key issues in agriculture sector (14). Only 5.6% of the European farms were managed by farmers under the age of 35, while over 31% of the farmers were over the age of 65 (15), and just 10.6% of the farms had managers under the age of 40 in 2016 (Eurostat[2]). The data correlate with Kołodziejczak (16) research findings, which have shown that one of the highest rates of employment in agriculture were registered in Romania, Bulgaria, Poland, Latvia, Lithuania and Croatia, while the rate of young people involved in the agricultural workforce was insignificant. The same inconsistencies were found by Janeska (17) analyzing the employment in the Republic of North Macedonia, showing an intensified process of demographic aging in agriculture. The situation of aging work force in the agriculture sector is not specific to the EU only, and, according to Jöhr (18), the average age of farmers in the US was then 58, in Japan – 67.

Agriculture creates negative stereotypes, and young people are moving from rural to urban areas. Still a major problem in the EU is the high level of youth unemployment (under 25), which was 17% in 2021(Eurostat[3]). Young people's attitudes toward work, in agriculture are formed at an early age (19), so it is important to consider the reasons behind the encouragement of a certain job choice. Negative stereotypes do not support EU agriculture in shifting to a sustainable future. That highlights how important it is to attract young people to agriculture. A comprehensive literature review has revealed the existence of certain stereotypes relating to the farmers' image, as well as working conditions, social status and other (3, 20–22). Lundy et al. (23) found out that both young people and adults had a stereotyped concept of agricultural workers. The workers were associated with a rugged, tan man working outside. Therefore, despite the multiple innovations being implemented by the agriculture as a job creator to reduce unemployment in the EU, attracting young people remains a challenge. To build a different image of agriculture among the youth, it is necessary to change young people's mindset today, but this requires assessment of how young people view agriculture at present. In this context, the present study focuses on analysis of the factors affecting the youth's (un)willingness to work in agriculture using Lithuania as a case study. This analysis may allow and its results are necessary for the scientific community, policy makers, farmers, and practitioners exploring the possibilities for integration of the youth into the agricultural workforce.

Materials and methods

Case study: Labor situation in agriculture in Lithuania

Lithuania is characterized by a strong focus on the development of rural regions, as approximately one-third of Lithuania's population live in the rural areas.

2 Eurostat database. Access: https://ec.europa.eu/eurostat/web/main/data/database.

3 Eurostat database. Access: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Unemployment_statistics#Youth_unemployment.

According to the National Land Service[4] in Lithuania, more than 80% of the area are rural, 52 % of the surface land is agricultural land, and arable land covers 46% in 2021. Therefore, Lithuania has a strong potential for work in the agricultural sector. According to the year 2019 database of the Lithuanian Employment Service[5], the role of the agriculture sector in the Lithuanian economy was declining over the last decade, and the value added of agriculture declined as well. This was influenced by the decline of rural population: the average of 9 thousand people would leave rural areas for urban areas every year. According to the population migration data, the rural population halved within the last 50-year period. According to the data by Statistics Lithuania[6], the number of permanent residents in rural areas in Lithuania decreased by 26.5 thousand between 2016 and 2019. The decreasing population in rural areas is affected not only by urbanization, but also by the growing size of farms. The average farm size by agricultural area increased from 11 hectare to 20 hectares from 2005 to 2016 (Statistics Lithuania). The implications of the growing size of farms influence the integration of young people into agriculture with the possibility to have an own farm. However, farm growth cannot be viewed only as a negative phenomenon as it creates new workplaces. The number of employees in agriculture increased almost twice over the decades, from 24 k employees to 40 k employees between 2005 and 2016 (Statistics Lithuania). Agriculture remains an important employer in Lithuania and contributes to the development of the country's economy, employment of the population, food supply, etc.

The Lithuanian agriculture sector has been undergoing substantial restructuring upon Lithuania's accession to the EU in 2004 (24, 25). Main changes have been prompted by adaptation of the EU CAP (24), the economic crisis in 2009, the Russian embargo in 2012 (26), as well as the recent Covid-19 pandemic. The Lithuanian government has been focusing on various instruments to support the fintech and service sectors, and the average salary in agriculture has decreased compared to the national average salary (26). The threat posed to agriculture by the rising wages in other sectors is also mentioned in the report by the Lithuanian Institute of Agrarian Economics (27) on the assessment of the economic, social and environmental situation of Lithuanian agriculture and rural areas. The above facts may be considered as some of the reasons behind young people's reluctance to choose to work in agriculture. Agriculture is becoming unattractive due to lower wages, economic and political difficulties, and governmental support to other business areas that also need specialists. These factors may lead to the situation where rural youth opt for non-agricultural careers and move to the cities.

Despite the above implications, the agriculture sector is one of the core economic sectors in Lithuania and employs about 8% of the national labor force (26). The analysis of statistical data shows that Lithuania has a rural population aging problem, as farmers are predominantly in the age group above 50. A very small share of those employed in agriculture are under the age of 29 (Statistics Lithuania). According to the data by Statistics Lithuania, the internal migration of the population from rural to urban areas in 2020 increased by as many as 14% compared to 2016. According to the data by the Lithuanian Employment Service[7], persons over the age of 50 made the largest share of seasonal employees in agriculture, making about 46% of all the employed in 2020. The report by the Lithuanian Institute of Agrarian Economics (27) points at the issue of aging of the agrarian society in Lithuania that leads to increased reluctance among the young people to live and work in the countryside. This is partly due to the unattractiveness of farming as an economic activity (its routine nature, uninterrupted production cycle, unconventional working days). There has been an increase in the number of young farmers, but they are not actively engaged in farming activities despite enjoying the benefits of residence in rural areas. This poses a threat to the uninterrupted generational change in agriculture and the continuation of farming traditions.

In 2020, youth (up to 24 years) unemployment accounted for 11.9% of the unemployed in Lithuania, while unemployment in other age groups ranged from 5 to 8% (Statistics Lithuania). The number of people employed in agriculture could actually be higher taking in account the lack of workforce in the agriculture sector and the high unemployment rate among young people. According to the Lithuanian Employment Service[8], the agriculture sector is facing a labor shortage of 27.3% in 2021. One of the negative factors is that the agriculture sector is facing the deficit of educated labor force in Lithuania. Another limiting factor is that rural regions are historically associated with agriculture in Lithuania, creating barriers to change the economic structure of regions in Lithuania (25).

4 National Land Service under the Ministry of Agriculture of the Republic of Lithuania. Access: http://www.nzt.lt/go.php/lit/Lietuvos-respublikos-zemes-fondas.

5 Employment Service Under the Ministry of Social Security and Labor of the Republic of Lithuania. Access: https://uzt.lt/wp-content/uploads/2019/07/%C5%BDem%C4%97s-%C5%ABkio-sektoriaus-tendencij%C5%B3-ap%C5%BEvalga-2019-06.pdf.

6 Statistics Lithuania. Access: https://www.stat.gov.lt/home.

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Dairy and animal husbandry activities prevailed in Lithuania before its accession to the EU. Afterwards, a lot of farms started growing grain and rapeseed crops, today accounting for about 55%, which has led to the need for structural changes in the agriculture of rural regions (25). This issue is caused by the lack of innovative development of higher value-added products and shortage of labor, in particular skilled labor, in rural areas (27). Volkov et al. (24) have disclosed another existing issue related to large number of farms on the Lithuanian market despite the growth in farm size. Certain farms have low profitability, and given that the majority of farms are run by older people approaching retirement, it is difficult to maintain the previous level of labor demand in agriculture. This reveals the existing issue of a high unemployment rate among the Lithuanian youth and shortage of labor force in agriculture. This shows that the issues of youth employment in agriculture needs to be discussed and addressed.

In Lithuania, same as in the EU, it is important to take into account the recommendation by the European Council (2020/C 372/01) (28) "A Bridge to Jobs – Reinforcing the Youth Guarantee" superseding the 2013 Youth Guarantee. The recommendations include strengthening of the prevention of youth unemployment and inactivity; preparation of young people for the new labor market; introduction of the youth to the need for lifelong learning; in-service training or retraining with a focus on 'green' or digital skills, etc. Therefore, the present study may help reveal the reasons behind the young people's unwillingness to work in agriculture, and the results of the study may contribute to an informed decision-making related to reduction of the youth unemployment. The report by the Lithuanian Institute of Agrarian Economics (27) on the assessment of the economic, social and environmental situation of Lithuanian agriculture and rural areas has revealed a series of existing related issues: young farmers' reluctance to pursue development in regions remote from major cities; lack of free land; lack of capital for young farmers to set up new farms; deteriorating infrastructure in rural areas as a barrier to generational change; rising wages in other sectors of the economy affecting the attractiveness of farming for young people.

In order to address young people's reluctance to live in rural areas and work in agriculture, it is necessary to put a stop to the deterioration of the demographic situation in rural areas and redirect the population migration in Lithuania. In order to keep young people in the countryside and attract new ones, conditions must be created for them to engage in the desired activities in rural areas, enabling them to generate sufficient income. Therefore, favorable conditions must be created for business start-up initiatives in rural areas (27).

Research methodology

Youth's (un)willingness to work in agriculture sector was measured by using two binary variables, which took a value of 1 when an individual i) had the priority to work in the agricultural sector (PRIOR_AGR); and ii) was willing to work in the agricultural sector (LIKE_AGR), and 0 – otherwise. Given that the dependent variable was dichotomous, its relationship with independent (explanatory) variables was estimated using a binary logistic regression model, as in (29, 30). Equation 1 shows the general formula for BLR model:

$$\mathbf{Y_{ij}} = \alpha_{\mathbf{i}} + \beta_{\mathbf{j}} \sum_{\mathbf{ix1}}^{\mathbf{n}} \mathbf{X_{ij}} + \mathbf{e_i}$$

Where: Y_{ij} is the dependent variable (priority to work in the agricultural sector or willingness to work in the agricultural sector), $\sum_{jx1}^{n} X_{ij}$ is the sum of independent (explanatory) variables (socio-demographical characteristics and perception variables) for jth of the respondent, $\alpha_j \ldots \beta_j$, are the estimated coefficients, e_i—the error term.

The study considered the following socio-demographical characteristics: gender (encoded as 1=male, 0 = female), area of residence (RESID) (encoded as 1 = village, 0 = city), family persons engaged in agricultural activities (PER_AGR), and relatives or acquaintances working in agriculture (REL_AGR) (encoded as 1 = yes, 0 = no). In addition, three groups of questions revealing perceptions, which could encourage/discourage people to work in agriculture, were analyzed: i) individual perceptions; ii) economic perceptions; and iii) social perceptions, as proposed by Magagula et al. (31). The answers to the questions, such as what conditions would encourage employment in the agriculture sector (in the groups of perceptions), were ranked based on Likert scale (1 = totally disagree; 2 = disagree; 3 = do not have an opinion; 4 = agree; 5 = totally agree). Explanation of perceptions and statement variables presented in Table 1. Statements in the questionnaire were constructed taking into account/under the assumption that the stereotypes relating to the farmers' image and work in agriculture do exist. Here, mostly based on (6b) and other literature, questions were developed to help the researchers identify the aspects of different stereotypes that are relevant to the youth. Later the developed questionnaire was discussed and approved in the group meetings of the COST Action.

In order to investigate whether work in agriculture would be a priority for young people (PRIOR_AGR) and whether they would like to work in agriculture (LIKE_AGR), two BLR models were created. Model 1 was based on the question *would working in the agricultural sector be a priority for you*, while model 2 was based on the question *would you like to work in the agricultural sector*.

The models were developed using the Stepwise Method of Forward Stepwise function in SPSS to avoid the problem

of multicollinearity. Independent variables, tested as potential predictor variables, were socio-demographic characteristics: gender (GENDER), area of residence (RESID), family persons engaged in agricultural activities (PER_AGR), and relatives or acquaintances working in agriculture (REL_AGR). They were coded as dummy variables value (1 and 0). Other independent variables of individual, economic and social perceptions, coded to Likert scale, had the values of 1 to 5. In total, 31 (27 perception variables, and 4 socio-demographic variables) factors were included in each model and checked. All statistically insignificant variables were excluded from the final BLR models, i.e., final BLR models were considered and the results were analyzed using only the significant variables.

The target population of research are young people in Lithuania. According to the definition of youth population provided by the European Commission (32), this is the total number of young people in the age groups 15–19, 20–24, and 25–29 living in a member state of the European Union on January 1st. The target population of the research was young people in the age group 15–19, since they had not yet chosen the prospective profession, were not studying a particular subject at university, college or vocational school. This choice was based on the aim to explore the factors behind the young people's willingness to work in agriculture, as they had probably not yet chosen a field of study or direction of work opportunities and still had the possibility to plan their occupation or even studies in agriculture field. Therefore, the focus was placed on young people, still learning at school.

As the target population was selected young people in Lithuania we considered Lithuanian law principles that young people till 13 years old need to have permission of the parents to be asked. Here, according to Civil Code of the Republic of Lithuania[9] article 2.8 youth from 14 till 18 years could make decisions and small/ daily contracts, receive revenue from activities and control their finance and banks. In other words, these group of young people takes responsibilities themselves for obligations, and could be suitable to participate in present research about their perceptions toward working in agriculture.

TABLE 1 Description of perceptions independent variables used in the BLR models.

Perceptions	Statement in the questionnaire
Individual	• Young people should work in agriculture (AGR_YOU) • It is an opportunity to have your own farm (FARM_OP) • I would like to work in agriculture because I love nature and animals (LIKE_NAT) • I would choose to work in agriculture only abroad (AGR_ABR) • No conditions would encourage me to work (WORK_NO) • Specialized training in agriculture would encourage me to work (SPEC_TR)
Economic	• Work in agriculture is low paid (AGR_PAID) • Agricultural work is seasonal (AGR_SEA) • Working in agriculture does not provide opportunities for self-realization (AGR_SR) • Working in agriculture is profitable (AGR_PROF) • The agricultural sector is well developed and will always remain significant (AGR_SIG) • No development in agriculture (NO_DEV) • Modern farmers have a lot of financial resources (FIN_RES) • Technological innovations make work in agriculture more attractive (AGR_TECH) • Higher salary / wage (WAGE)
Social	• Work in agriculture is dirty (AGR_DIRT) • Working in agriculture is physically difficult (AGR_DIF) • Working in agriculture is dangerous (AGR_DAN) • Working in agriculture is not prestigious (AGR_NOPR) • Working in a natural environment (WORK_ENW) • Agricultural work is for unskilled workers (AGR_UNSK) • Working in agriculture is a life-style (AGR_LS) • Work in agriculture is responsible (AGR_RES) • Incomplete social life in rural areas for young people (AGR_NOSL) • Flexible work schedule (WORK_SCHED) • Nature of work (WORK_NAT) • Feeling the difference between urban and rural lifestyles (FEEL_DIF)

Sampling characteristics

The main survey was conducted in the period from December 2020 to April 2021. Due to the pandemic situation related to Covid-19, the survey was implemented online in the attempt to involve young people willing to fill out the questionnaire. Therefore, 444 questionnaires were completed, with only a few questionnaires rejected as completed inappropriately. Data of 430 questionnaires were registered and analyzed. According to Israel (33) and in view of the target population size, the number of questionnaires collected ensure a statistical error between 5 and 7%. Hence, sample size $N = 430$ assured that the analysis of 430 questionnaires would reflect the total sample ($N = 130\ 926$; young people the age 15–19 living in Lithuania in 2020 by Eurostat), with 95 % confidence level and $\pm$ 5% sampling error. The descriptive statistics of the respondents' main sociodemographic characteristics are presented in Table 2.

Identifying the factors of youth's motivation to work in agriculture toward their individual, economic and social perceptions were analyzed. Descriptive statistics have suggested

9 Civil Code of the Republic of Lithuania. Access: https://www.e-tar.lt/portal/lt/legalAct/TAR.8A39C83848CB/asr.

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TABLE 2 Respondents' socio-demographic profile ($N = 430$).

Variables	Study sample	
	N	%
Gender		
Male	166	38.6
Female	264	61.4
Age (15-19)		
15–16	144	66.66
17–19	286	33.4
Area of residence		
City	274	63.7
Village	156	36.3

that higher salary could seem to be the best motivating factor to choose work in agriculture, and more than 73% of the respondents agreed with this statement. It was followed by the flexible work schedule (66%). About half of the respondents agreed that the nature of the work and conditions could encourage them to work for the agricultural sector. A few respondents would be motivated to work in agriculture if offered various training and qualification courses. It turned out that only about 15% of the respondents would not work in agriculture under any condition. Half of the respondents thought that the agricultural sector would remain significant and was well-developed, while the other respondents did not share that opinion and believed that there was no development in the agriculture sector. Only 20% of the respondents stated that the social life was not fulfilling for young people engaged in agriculture. More than 60% of the respondents thought that the technological innovations transformed agriculture into an attractive place to work.

The major share of the respondents thought that work in agriculture required a great deal of responsibility. A considerable part of the respondents did not agree that work in agriculture was for unskilled people. More than half of the respondents had no opinion about self-realization in the working in agriculture. It should be noted that the majority of them had difficulties in finding work in agriculture, and the minority thought that work in agriculture was low paid. About half of the respondents had no opinion about the attractiveness of work in agriculture. The results of the survey showed that about half of the respondents did not have any opinion on whether young people should work in agriculture or not. Most of them agreed that work in agriculture provided an opportunity to have own business, and more than half of the respondents disagreed to the statement claiming that they would choose to work in agriculture abroad only.

Results

Using Forward Stepwise method, 10- and 6-step actions were performed in the first and in the second model respectively. The selected models were formed in step 6 of both models. Table 3 provides information on the goodness of fit of BLR model.

As presented in Table 3, the Omnibus tests assess the goodness of fit of the models incorporating the statistically significant variables. Sig. ($p = 0.000$) shows that model is statistically significant and the dependent variable is well predicted. The Chi-Square test explained a significant amount of the original variability, x^2 $(6, N = 430) = 88.424$ in the first model and x^2 $(6, N = 430) = 131.045$ in the second model. The data of models indicate that both models are reliable; therefore, the obtained models' results can be interpreted and the existing stereotypes affecting the Lithuanian young people's desire to work in agriculture can be assessed. Model 1 presents the cases where young people see the priority in working in agriculture (see Table 4).

Table 4 shows the results of the BLR model 1 and its goodness of fit. The Nagelkerke modification is considered to be a more reliable measure of the ratio compared to Cox and Snell's. In this model, Nagelkerke, R^2 accounts for 0.302, indicating 30.2 % relationship between the predictors and the prediction. The overall percentage of correct recognition of the first model is 84.20 %. The BLR results show that socio-demographical characteristics, individual, and social perceptions about the work in agriculture influenced youth' decision to see the work in agriculture as priority: i) women were less likely to choose work in agriculture; ii) the young people living in urban areas were less willing to choose agriculture as the priority in comparison to those living in rural areas. iii) youth whose parents were engaged in agricultural activities iv) and who loved nature and animals (LIKE_NAT), were most likely to choose the work in agriculture as a priority. The respondents who believed that young people should work in agriculture (AGR_YOU) were more inclined to choose work in agriculture as a priority. However, the opinion related to unsatisfactory social life in rural areas (AGR_NOSL) for young people was associated with decreased priority among the young people to work in agriculture.

Table 5 shows the results of the BLR model 2 and its goodness of fit. The R-squared values. Here, Nagelkerke, R^2 accounts for 0.399, indicating a 39.9 % relationship between the predictors and the prediction. The overall percentage of correct recognition of the second model is 83.3%, indicating that the both models provide correct classification of the cases.

Table 5 shows the results of BLR analysis, presenting youth's willingness to work in agriculture sector. The BLR results show that socio-demographical characteristics, individual, economic and social perceptions about the work in agriculture variable influence youth's willingness to work in agriculture. The results show that gender had a negative effect and significantly reduced the willingness to work in

TABLE 3 Information of the goodness of model fit.

Model	Omnibus tests of model's coefficients	Chi-Square	df	Sig.
1	Step	4.853	1	0.028
	Block	88.424	6	0.000
	Model	88.424	6	0.000
2	Step	6.388	1	0.011
	Block	131.045	6	0.000
	Model	131.045	6	0.000

TABLE 4 Result of BLR model 1.

	B	S.E.	Wald	df	sig	Exp(B)	B
GENDER	−0.634	0.288	4.853	1	0.028	0.530	−0.634
RESID	−0.915	0.290	9.928	1	0.002	0.401	−0.915
PER_AGR	0.936	0.292	10.297	1	0.001	2.549	0.936
LIKE_NAT	0.686	0.172	15.901	1	0.000	1.986	0.686
AGR_YOU	0.496	0.165	9.100	1	0.003	1.643	0.496
AGR_NOSL	−0.381	0.144	7.005	1	0.008	0.683	−0.381
Constant	−4.103	0.920	19.907	1	0.000	0.017	−4.103
−2 Log likelihood	321.787						
Pseudo R-squared:							
Cox and Snell	0.186						
Nagelkerke	0.302						
Overall Percentage	84.20%						
Observations	430						

Variable significant at 1%.

agriculture (as in BLR model 1 as well), and women were less likely willing to work in agriculture (by 1.22 times) than men. The findings have shown that youth's willingness to work in agriculture increased due to specialized training in agriculture (SPEC_TR), love of nature and animals (LIKE_NAT), and as well as youth's belief that they should work in agriculture (AGR_YOU) and opinion that work in agriculture was profitable (AGR_PROF). Youth's belief that work in agriculture did not offer any opportunities for self-realization (AGR_SR) reduced their willingness to work in agriculture. It could be assumed that the research showed the importance of the financial factors when choosing to work in agriculture.

Discussion

The findings of the present research about youth's (un)willingness to work in agriculture and the factors determining this decision are in line with previous studies. The results have suggested that gender was the factor influencing the willingness to work in agriculture. Similar results were found by Elias et al. (34), namely, that females did not seek a career in agriculture dominated by males. Recent research in Lithuania has shown that there is no large gender gap in agriculture, nonetheless it also indicates that women are more interested in non-agricultural activities, which coincides with our research (34).

The findings show that the area of residence (youth from rural areas were more willing to choose work in agriculture as a priority) had a statistically significant influence on prioritization of work in agriculture. This is an expected result supported by the literature (35), revealing that the youth who has strong connection with their home village will likely stay to work at their family farm. Otherwise, the youth is usually willing to migrate because of family reasons, job opportunities or education (35). Ridha and Wahyu (36) and Aziz and Naem (37) found that the motivation to work in the agriculture sector would stem from parents, family, who are working in agriculture. The research by Simõesa and do Rio (38) revealed that positive perceptions about the work in agriculture sector originating in the family increased the youth's motivation to

TABLE 5 Result of BLR model 2.

	B	S.E.	Wald	df	sig	Exp(B)	B
GENDER	−1.221	0.296	17.076	1	0.000	0.295	−1.221
SPEC_TR	0.394	0.154	6.575	1	0.010	1.483	0.394
LIKE_NAT	1.013	0.185	29.875	1	0.000	2.753	1.013
AGR_SR	−0.659	0.172	14.639	1	0.000	0.517	−0.659
AGR_PROF	0.457	0.184	6.141	1	0.013	1.580	0.457
AGR_YOU	0.528	0.165	10.294	1	0.001	1.696	0.528
Constant	−7.312	1.183	38.214	1	0.000	0.001	−7.312
−2 Log likelihood	330.547						
Pseudo R-squared:							
Cox and Snell	0.263						
Nagelkerke	0.399						
Overall Percentage	83.30%						
Observations	430						

Variable significant at 1%.

work in this sector. The same findings were indicated by the present research. Our research has revealed that loving nature and animals increased youth's willingness to choose work in agriculture, and seeing it as priority, thus substantiating the conclusions of the previous research (39).

Our results underlined that specialized training in agriculture (SPEC_TR) had a statistically significant impact on the youth's intentions to work in agriculture. This implies that having a specialized training would also motivate young people to work in agriculture, thus substantiating the findings by Cecchini et al. (1), Magagula et al. (29), and Simõesa and do Rio (38). Present research found a positive link between positive attitude and intention/willingness to work in agriculture, which is in line with the previous studies (40, 41). However, youth's negative opinion about opportunities for self-realization (AGR_SR) in agriculture reduced their intentions to work in agriculture. Similar results were found by Akrong and Kotu (42) stressing the negative perceptions among the youth about agribusiness. Vankov et al. (43) have noticed that the youth's desire of self-realization and desire to become entrepreneur may be affected by cultural or geographical factors. In particular, the authors draw attention to the fact that in the developed nations, the youth have lower intentions than those in the developing countries. Meanwhile, Zhartay et al. (44) mark specific age, personal characteristics of young people, their social status, mobility, activity and adaptability as important factors for self-realization in entrepreneurial. Therefore, decision to start business in the agriculture sector may be related less to the specifics of agriculture sector and more with the social-demographic reasons.

This was an expected result as work in agriculture was not economically encouraging and required wider promotion among the young people (31, 36, 45, 46). According to Finger and Benni (47) farm income depends on such variables as the increasing complexity of farms, increasing risk of exposure, and increasing complexity of agricultural policies and policy measures. It is therefore understandable why this sector does not look so attractive for the youth.

The present study is in line with the CFS Policy Recommendations on Promoting Youth Engagement and Employment in Agriculture and Food Systems (48) stressing the same aspects as equity and distribution of resources across generations, appropriate infrastructure for young people life, and ensuring appropriate social life. The present study showed the need to attract young people to work in agriculture and the need for policy instruments. This finding supports the results of Mujčinović et al. (49) who analyzed the possibility to tackle the need for the youth by the means of agricultural and rural development policy in 28 EU countries and Bosnia and Herzegovina, North Macedonia and Serbia. Their comparative analysis indicated the need for the policy aimed at attracting young people to work in agriculture. However, they also found differences between the regional development policies among post-transitional countries and between the potential to adapt modern European practices and policies.

Conclusions

The present study was a part of the COST action CA16123 "Safety Culture and Risk Management in Agriculture." The focus of the study was to analyze the reasons behind the youth's (un)willingness of work in agriculture, using Lithuania as the case study. Ac-cording to the agricultural characteristics of Lithuania, the agriculture sector plays an important role for the whole economy of the country. The obtained research results may find practical application in development of programs

for attraction and integration of the youth as the agricultural workforce. Agriculture is developing, innovating, and requires skilled workers. Therefore, agriculture should be presented as an innovative, technologically advanced sector, where self-realization is possible by creating own business. Only in this way young people will be attracted to agriculture and accelerate its efficiency, sustainability, contributing to achievement of the goals of the Green Deal. The necessity to develop infrastructure and create attractive leisure facilities for young people in rural are-as is another important issue in terms of youth attraction in agriculture. Funding for agriculture must be properly targeted at the infrastructure necessary for young people's social life and application of new technologies in agriculture.

Summarizing the results of current research, it can be stated that there are a few positive stereotypes: i) the youth see the need of trainings for working in agriculture; ii) they think that young people should work in agriculture. However, the research has revealed that the Lithuanian youth pointed at a number of negative stereotypes influencing their decision regarding the choice to work in agriculture: i) the youth thought that the social life in rural areas for young people was incomplete, and ii) they believed that there was no opportunity for self-realization in agricultural work. In addition, it should be noted that these stereotypes could be adjusted using a variety of measures, such as training, educational programs, etc. This could help change youth perceptions toward work in agriculture, taking into consideration their personal characteristics. Our research has revealed that one of the most important personal qualities in young people is love of nature and animals, making them willing to work in agriculture.

In addition to the positive and negative stereotypes about agriculture, other important socio-demographic characteristics were noticed. The desire to work in agriculture was determined by family activities in this field, as well as the living area. This only confirms that the formation of positive and negative stereotypes in agriculture can be influenced by the place of residence (city or village) and family activities (work in agriculture or another sector). Another important socio-demographic characteristic was the gender, as confirmed by the results and other researchers as well. Males are arguably more likely to choose the agricultural sector. It was also observed in our study that the unwillingness to work in agriculture would be higher among females. On the other hand, other studies confirmed that gender equality in agriculture was maintained in Lithuania; therefore, our study could be influenced by the fact that more females participated in the survey.

It should be noted that the present study had limitations, as it purposefully covered only the young people in the age group 15–19. Therefore, a more complex study could be carried out in the future. The further steps of the research will be the analysis of the youth's perceptions about different kinds of training and courses related to agricultural work. The present study has revealed that training has a positive effect on the willingness to work in agriculture. This may have been influenced by the fact that the youth participated in individual lessons about agriculture in schools.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

LG, EB, AuN, and AnN contributed to preparation of methodology and collecting and analyzing the data. All authors contributed to the conceptualization, design, writing and editing of the article, read, reviewed, and approved the final paper and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Safeguarding youth from agricultural injury and illness: Perspectives from Burkina Faso

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Current situation

In developing countries, the agricultural sector is the main provider of employment for the majority of the population (1). In Burkina Faso, this sector occupies 75% of the working population who live mostly in rural areas (2). Burkina Faso is a landlocked country located in the heart of West Africa with an estimated population of about 20 and a half million (3), according to the 2019 population census. The major types of agriculture are crop production, animal husbandry, and exploitation of non-timber forest products (NTFPs). Crop production is dominated by sorghum, millet, corn and rice, the main food crops, and cotton, which is the main cash crop. Most farms are family-based, small, and located in rural areas, utilizing numerous child workers daily. These farmers practice subsistence agriculture in a context where the rural area contributes the most to poverty in the country at 91.8% (2).

According to data from the 2006 National Child Labor Survey (4), 41.1% of children aged 5 to 17 are economically active in Burkina Faso. Of these, 95.8% are in child labor, with the agricultural sector being one of the most affected sectors at 69.2%. Regardless of the type of agricultural work, it involves several tasks that expose children to numerous risks. These risks are related to climatic conditions; the seasonal and physical nature of the activity; contact with animals and plants (bites, poisoning, infections, parasites, allergies, and intoxications); to exposure to chemical products. Unsafe pesticide use is a major problem in the agricultural sector in Burkina Faso (5), leading to illness or death. In September 2019, 18 people (13 from the same family) died from pesticide-related illness,[1] while in 2016, a study revealed that 341 in three regions of Burkina Faso suffered from pesticide-related illnesses.[2] The legal framework for pesticide use exists but the law is not enforced.

1 https://www.bbc.com/afrique/monde-49669368#:~:text=Un%20fermier%20africain%20r%C3%A9pand%20des,la%20ministre%20de%20la%20sant%C3%A9 (accessed June 28, 2022).

2 https://cenozo.org/consommation-de-legumes-au-burkina-faso-ce-danger-lie-aux-pesticides-du-coton/ (accessed June 29, 2022).

When children have a minimum legal age to work, the agricultural sector is the one that offers, beyond the daily risks, the most possibilities to work decently. Given the importance of the agricultural sector for the country's economic development, knowing the conditions for creating a safe environment for children is necessary for the implementation of good measures for their protection.

Burkina Faso recognizes the rights of children as the ratification of several conventions indicate. These include ILO Convention No. 5 on the Minimum Age for Admission to Employment in Industry, Convention No. 138 on the Minimum Age for Admission to Employment, and Convention No. 182 on the Worst Forms of Child Labor. No specific law regarding the health, safety, and wellbeing of children and adolescents on farms exists so far, but the country ratified the Convention No. 184 on health and safety in agriculture in 2009.

Current activities

The national laws are in place to specifically protect children, including Law 11/92 of 22/12/1992 on the Labor Code, Order N°539 ITLS-HV of 29/07/1954 on child labor, and Order N°958 FPT/DGTLS of 07/10/1976 on the apprenticeship contract (6). Within the Ministry in charge of social affairs, the General Directorate for the Protection of Children and Adolescents was created to better ensure that children's rights are respected. This directorate is made up of three departments: the department for placements and adoptions; the department for the supervision and promotion of early childhood; and the department for the protection and fight against violence against children.

The Permanent Secretariat of the National Plan of Action for Children (SP/CNSPDE) has been set up to coordinate and monitor all actions to ensure that children's rights are respected. The secretariate has a website[1] but it is not updated. A series of training courses and conferences on children's rights are held each year for staff working with and/or for children. These include social workers, health workers, magistrates, primary and secondary school teachers, police officers, gendarmes, prison security guards, students in vocational schools, customary and religious leaders, political and administrative authorities, leaders of associations, and NGOs. Since the start of the 2006–2007 academic year, a module on the rights of the child has been taught in national professional training schools for workers from justice, police, and social departments: Ecole Nationale d'Administration et de la Magistrature (ENAM), Ecole Nationale de la Police (ENP), Ecole Nationale de la Gendarmerie (ENG), and Institut National de Formation en Travail Social (INFTS).

In terms of activities, several initiatives are being taken in Burkina Faso. For example, a new national survey on child labor is underway to update the 2006 statistics. This is part of the implementation of the 2019–2023 National Strategy to combat the worst forms of child labor. In addition, Burkina Faso's national development framework, the National Economic and Social Development Plan, includes the fight against child labor as a priority; the objective was to "reduce the prevalence of children aged 5–17 involved in economic activities from 41% in 2006 to 25% in 2020." An evaluation is underway to assess the achievements.

Non-governmental organizations have also taken initiatives to help protect children on farms. For instance, Terre des Hommes has supported the creation and implementation of community watch bodies named "Comités villageois de surveillance, CSV" (village surveillance committees) in two communes of Kénédougou province renowned for their orchard production to contribute to government efforts to curb child worst form of labor (7). The CSVs work on raising awareness about child protection from the worst forms of labor and developed community outreach, as well as mechanisms for controlling the movement of children.

Current challenges

Improving the health, safety, and wellbeing of children and adolescents on farms in Burkina Faso comes with enormous and multi-faceted challenges. We identify five main categories of factors, namely, economic stability, education, social and community context, health and health care, and the neighborhood and built environment.

Poverty incidence in Burkina Faso remains high (41.4% in 2018) with the rural sector as the largest contributor (91.8%) (2). Poor households tend to use family labor much more than non-poor households; the latter have more resources for labor hire. Under these conditions, the presence of child laborers on family farms contributing to agricultural labor is more common. The fight against poverty remains a major challenge in this case to ensure the safety and wellbeing of children in these households.

In a country, economic instability can create uncertainty and reduce investment opportunities, which are obstacles to growth and economic development. Burkina Faso has been living under a regime of exception since the beginning of 2022, following a political coup d'état that has led to certain sanctions, such as the suspension of the country from many regional and international organizations. The country faces a crisis marked by strong fluctuations in economic activity and inflation. The challenge is to reduce, as much as possible, the instability in the country while maintaining the capacity of the economy to improve living standards.

Another reason why many children are available for work on farms is because of low school enrollment rates. Indeed, in the area of education, the challenges are enormous, as the population is predominantly illiterate (61.7%). For young

1 https://www.sp-cnspe.gov.bf/#:\sim:text=Le%20SP%2FCNSPDE%20est%20plac%C3%A9,l'Enfant%20(CNSPDE) (accessed June 25, 2022).

people aged 15–24, the illiteracy rate is 13.4% in urban areas compared to 53.6.4% in rural areas (2). Policies to improve school enrollment rates should reduce the presence of children in the fields.

Beyond poverty, instability, and illiteracy, one of the biggest challenges is the social and community context. The Sahelian states have been experiencing unprecedented security and humanitarian crisis for several years, especially since the war in Libya. These countries are subject to recurrent attacks that make travel in some areas quite risky. Many people continue to flee and move to more secure areas. According to the United Nations High Commissioner for Refugees, there were more than 1.5 million internally displaced persons (IDPs) by the end of 2021, and Burkina Faso alone now accounts for 60% of the Sahel region's IDPs. As of the end of April 2022, there are 4,148 school closed because of insecurity, which means many children are forced to be out of school[4]. Therefore, there is a need to step up efforts to bring back stability for the proposed solutions to be sustainable.

Future direction

Current data collection gives hope for future policy interventions regarding measures to improve the health, safety, and wellbeing of children involved in agricultural activities. To improve health, safety, and wellbeing of children, we must first document the prevalence of injuries that children sustain while being involved in agricultural activities. Several ministries should be involved in collecting this information on a regular basis: the ministry of health, the ministry of social affairs, the ministry of labor and youth, and the ministry of agriculture.

Documenting the issue should be followed by disseminating the information through websites, radio, TV, and live discussion in communities, where the prevalence of injuries is highest. Initiatives like the NGO Terre des Hommes' village surveillance committees should be encouraged in other parts of the country. Empowering local communities to develop endogenous mechanisms for protecting children involved in agricultural activities is one of the best ways to ensure sustainability of the actions taken. Training sessions for employers and farming families about the best practices on the use of pesticides, as well as safety measures to take on use agricultural equipment, would help reduce the number of injuries.

A specific law regarding health, safety, and wellbeing of children and adolescents on farms should be enacted to boost the existing general provisions on safety in agriculture. Yearly reports on the number of injuries sustained by children while working in agriculture-related activities should be produced and the trend should be monitored to take additional measures if needed.

Funding for supporting the different initiatives to protect child involved in agricultural activities should be sourced from taxes on imported pesticides. Ultimately, government vision and commitment to child safety in agriculture will be the key in securing the funding needed to implement the devised measures.

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WM and ST conducted the literature search. WM drafted sections Current activities and Future direction. ST drafted sections Current situation and Current challenges. All authors contributed to the full manuscript writing.

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4 https://www.panapress.com/4148-ecoles-fermees-a-cause-du-t-a_630721462-lang1.html (accessed June 29, 2022).

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Commentary: Perspectives from Argentina: Children and agricultural health and safety

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Current situation

Argentina, located in South America, with a population of 47,327,407 (1), is a farming and ranching country. Food production has an important and strategic place within the current economic situation given that it accounts for 15% of its GDP and 48% of its total exports (2).

Argentina lacks a unified consensus about the age limits for defining children or adolescents in the data collected. Although, information obtained from different sources helps clarify descriptions of children and adolescents living in rural areas. The national agricultural census provides a lower-bound estimate of children who might be exposed to agricultural risks. In 2018, there were 48,984 females and 51,610 males, under age 14 years living on farms (3). Meanwhile the Survey of Activities of Children and Adolescents provides a higher-bound estimate of children who might be exposed to agricultural risks. In 2017, 1,043,949 children (between 5 and 15 years-of-age) lived in rural areas, of which ~207,000 worked performing intensive domestic activities, agricultural tasks to support production for market or household consumption. Of the 194,236 adolescents aged 16 and 17 who live in rural areas, 44% carry out some work related to agricultural production (4).

Regarding rates of injuries to children, surveillance data are currently not available, preventing the drawing of clear conclusions for the purposes of this commentary (5). This is because while the Superintendent of Occupational Risks provides yearly data on work-related accidents for individuals aged 16–24, the data by incident is not disaggregated by age—preventing us from determining injuries impacting adolescents vs. young adults. The Directorate of Statistics and Health Information publishes reports on the causes of death of individuals according to age, sex, and province, but it does not determine if the death occurred in rural areas or if the person was a rural resident, farmworker, or farmer.

Although there are no official statistics on injuries in rural areas, journalistic sources provide insights. The majority of rural injuries in children and adolescents occurred during recreational activities, work, when accompanying working family members, or as a consequence of living in the countryside. Data collected by this author show that in 2013, 33 children under age 16 died, and 44 died in 2014 from injuries and diseases related to some agricultural/rural activity (6). In the last 5 years, another 229 cases of fatalities in children under age 17 were reported in the media. This information is surely incomplete, and likely under reported, because not all situations are published or reported.

The analysis of the cases published in the media shows the characteristics of rural injuries involving children are closely related to the region of the country where they occur. In the so-called "core zone," motor vehicle-crashes on rural roads or routes are most prevalent, involving children accompanying their parents for work. Changes in agricultural production including through the increasing use of high technology (i.e., direct sowing) and the consolidation in agricultural production means that families have been able to move away from their rural residences to live in nearby towns or cities. Therefore, farmers travel several times a week to the field to complete tasks and then return to town, increasing the weekly kilometers traveled and increasing the risk of a road accident. In other regions of the country, such as the Northwest, Northeast, Cuyo, and Patagonia, where the production requires permanent labor (livestock, fruit trees, orchards, yerbatales, etc.), the farmers and workers with their families are more permanent and reside on the farm. There the injuries to youth are related to things such as animals (mainly horses), drowning, and machinery (frequently the tractor).

Current activities

Laws and regulations protect children from child labor. In Argentina, child labor is defined as "any productive or service activity in which girls or boys under 16 years-of-age participate, regardless of their employment status (whether they receive payment for their work or not, be it family or for third parties), that hinders their schooling and/or that due to their environment or conditions implies current or future damage to their health and psychophysical development" (7). There are however, exceptions to this law, boys and girls between the ages of 14 and 15 whose parents operate a family business can work given the provisions of protective measures, such as a 3-h workday. Adolescent work (16 and 17 years old) is allowed but they are offered protections including: working no more than 6 h a day or 36 h a week; no work before 6 a.m. or after 8 p.m.; no work that is considered dangerous, arduous or unhealthy (8).

A few initiatives protect children from rural injuries. The RENATRE (National Registry of Rural Workers and Unloaders) has opened houses to accommodate minors while their parents work in the harvest in certain parts of the country (Grow Program) and thus distance them from the risks present in the workplace. Also since 2021, the government, together with unions and companies, promote the creation of Rural Socio-Educational Centers (CSER). These centers house the children of seasonal and migrant rural workers under 16 years during the harvest months. For example, in the Mendoza province, there are 48 of these centers, accommodating more than 3,000 children and adolescents under age 16. Children from other provinces such as Misiones, Salta, Tucumán, Jujuy, have benefited from this endeavor (9).

Current challenges

There are many challenges to protect the children in the field. Taking a closer look at the existing government actions to prevent rural injuries in children and adolescents, the majority are focused and directed only at children of temporary or migrant rural workers and adolescent workers covered by the work insurance system, leaving out of these initiatives other children and adolescents who live in or visit rural areas, for example children of farmers, children traveling for rural tourism, etc. Furthermore, the preventative activities financed and organized by agricultural machinery companies, agricultural foundations, and NGOs can largely be characterized as isolated, sporadic, and temporary initiatives without continuity. Often the objective is to improve the image of the organizer rather than a social service to prevent childhood injuries. Groups of rural women, from their agricultural cooperatives, have supported and developed education and training programs for producers, workers, and rural families to prevent injuries involving children, covering a very large gap that exists linked to the dissemination of preventive information.

Several important actors are also not currently addressing rural injury prevention which represent missed opportunities. This includes public organizations related to rural, the curriculum in rural and agritechnical schools, most government manuals and technical publications of companies or private institutions for the development of agricultural activities (such as agritourism and rural exhibitions). This also includes the lack of training or research in agricultural health and safety in medical schools, except for issues related to poisoning with agrochemicals. Positively, the SAP (Society of Argentine Pediatrics), does list the risks and ways to prevent injuries in rural areas in its Accident Prevention Manual (10).

Last, shortcomings in the prevention of rural injuries in children are observed daily in Argentina. For example, often in the media, images of children in risky situations in the field are shown as something charming or normal. In turn, the sensationalism of publishing news about a fatal case in the field is accompanied by varied details

(episodic stories), but without preventive recommendations for readers (absence of thematic stories). This is different than the reported news about roadway crashes, where information about risks is frequently included and detailed, and the causes are analyzed. It seems media ignore or minimize their power to help reduce injuries in agriculture. However, this could also be due to lack of knowledge of the subject.

Future direction

A range of changes is needed to improve the safety of rural Argentinian children. It is first necessary to improve the official registries to understand the prevalence and the types of injuries. This information is important for the development and refinement of agricultural health and safety interventions. Developing government programs on agricultural health and safety and injuries prevention is also urgently needed in Argentina. Having teachers at the primary (rural schools) and secondary level (agritechnical schools) educate their students in injury prevention could lead thousands of children to a safer childhood and adolescence, transferring this knowledge to their children in the future. This could help address the challenges around the risky habits and customs, so ingrained in Argentine country life. The creation of university study programs in agricultural health and safety for the qualification and training of health professionals in said area is relevant. Besides educational programs, the provision of childcare should be a fundamental pillar. All the proposed improvements require joint interdisciplinary and cooperative work between government agencies, educational institutions at all levels (schools, colleges, and universities), media, unions of rural workers and farmer's associations to be able to face and improve the dire statistics of childhood injuries that impact the Argentine countryside year after year. The private sector (e.g., agricultural machinery companies), through its corporate social responsibility, can complement these initiatives by contributing funds or material and human resources. Last, the media can contribute to increased injury prevention measures in different ways. One of them would be use images showing no risky situations for children. Another would be the correct use of language (for example, "incidents" instead of "accidents"), along with the incorporation of recommendations for the prevention of these incidents. The basis of all this contribution should begin with the training of journalists on this problem.

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Commentary: Highlighting the need for pesticides safety training in Nigeria: A survey of farm households in Rivers State

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A Commentary on

Pesticides-handling practices among smallholder vegetable farmers in Oyo state, Nigeria.

Ugwu, J., Omoloye, A. A., Asogwa, E. U., and Aduloju, A. R. (2015). *Sci Res J* 3:40–47; doi: 10.12895/jaeid.20181.697

Occupational insecticide exposure and perception of safety measures among cacao farmers in Southwestern Nigeria.

Sosan, M., and Akingbohungbe, A. (2009). *Arc Env Occ Health*. 64:3; doi: 10.1080/19338240903241077

Self-reported symptoms on farmers health and commonly used pesticides related to exposure in Kura, Kano State, Nigeria.

Raimi, M. (2021). *Annal Commy Med & Pub Health.* 1:1002

Current situation

Agriculture accounts for approximately a quarter of gross domestic product in Nigeria. Common products include dcassava, yam, maize, sorghum, rice, millet, palm oil, cocoa beans and pineapple. Agricultural activities are an important component of peri-urban and rural life in Nigeria, since 70% of households report participation in agriculture and 41% own livestock (1). The entire family—including farm youth—regularly assist with farm activities, including handling of fertilizers and pesticides. This is particularly the case in farming households where women are responsible for production, since they may encourage children and grandchildren to participate and work alongside for both productivity and security reasons (2). These youth are at high risk for exposure to agrochemicals due to their agricultural surroundings and involvement in production. Safe or unsafe handling practices are passed onto these youth at very young ages. Agrochemicals are often purchased at an agricultural supply store (in an open market) and then stored in the home. Previous studies have found that up to 30% of farm households reuse these agrochemical containers for other storage purposes—even for storing food seasonings and palm oil (3, 4).

Little is known about socioeconomic factors influencing access to appropriate safety controls for agrochemicals, including the use of personal protective equipment (PPE). This commentary describes current activities being done in Nigeria by Norina Farms to interview agricultural workers in Rivers State to inform development of more community-based, grassroots-style pesticides safety educational programs in the region. The purpose of these interviews was not research driven, rather they were conducted to ensure that the trainings addressed the needs of local farm households.

Current activities

Community interviews

In 2, Norina Farms interviewed 152 agricultural workers in Kom-kom, Obeama, Izuoma and Mmiriwanyi Oyigbo in Rivers State, Nigeria. Interviews were conducted in local Pidgin English with the agricultural family inside the home. The homes were selected based on proximity to the Norina Farms office location in Mmiriwanyi. A 10-kilometer geographic radius was identified around the centrally located office, and interviewers contacted all farm households in the region who were available at the time. IRB review for human subjects research was not required since the purpose of the interviews was to identify producer-informed practice solutions to improve a community-based pesticides training program. All agricultural workers (100%) were involved in both cassava and vegetable production, which is common in the region. Interviewers noted demographics, number of youths living in the home, types of pesticides used, and activities related to handling of agrochemicals to inform the training. All the workers reported agricultural youth (age 3 months to 22 years) living in the household.

Pesticides safety training

In 2018-19 Norina Farms provided a community-based pesticides safety educational program to more than 160 agricultural families in the same region. Agricultural youths as young as 15 years old were present at the training. Educational topics were customized based on the interviews and included (a) sharing stories and discussing adverse health effect experienced as a result of pesticides handling, (b) proper pesticide application methods according to the label, (c) PPE use described on the label and appropriate donning/doffing procedures, (d) proper agrochemicals storage, and (e) container disposal. Personal protective equipment (PPE), including reusable chemical resistant gloves and goggles were provided as incentives for attending the program.

Current challenges

In Nigeria, many agricultural households are reliant on inorganic fertilizers and pesticides yet have little access to safety controls, such as PPE, described on the label. The interviews conducted by Norina Farms revealed that the most common pesticides used included atrazine, chlorpyrifos, paraquat dichloride, glyphosate, and cypermethrin. Organophosphate pesticides, such as chlorpyrifos, were still reported on crops such as maize, millet, and cassava. This was like another study by Raimi (5), which reported pesticides such as atrazine, cypermethrin, and S-Metolachlor—although the study was limited to inquiring only about specific pesticide types.

Almost none of the agricultural workers (2%) interviewed reported proper use of PPE as stated on the pesticide label. For example, most pesticide labels containing atrazine require coveralls, long sleeves/long pants, and chemical resistant boots and gloves. Chlorpyrifos requires additional eye protection and respiratory protection. Among those interviewed, the only PPE-usage reported were the use of rubber gloves or cloth face coverings. Over half (66%) of participants reported wearing the same clothing in the home after working in the fields, potentially increasing the risk of exposure to others, including any youth, living in the home (6). Ugwu et al. (7) stated that up to 65% of Nigerian farmers reported wearing some form of PPE, with the most common including rubber gloves, protective overalls, and cloth face coverings. Adesuyi et al. (8) found that over 67% of Nigerian farmers near wore some form of PPE with the most common being chemical resistant gloves, hats, and boots. However, both other studies took place in other Nigerian states or near the city of Lagos. The reported use of PPE among this agricultural working population in Rivers State is very low in comparison and further highlights the importance of pesticide safety education efforts in the region.

All families reported little to no training on proper use of safety equipment or personal protective equipment (PPE), with cost and access reported as major barriers. For example, many of the workers did not know how to recognize and request appropriate PPE listed on the label when shopping for agrochemicals at the local agricultural supply store. They indicated that pesticides-related safety equipment is often unavailable at these stores. If PPE, such as chemical gloves, was obtained, several workers stated that it was uncomfortable due to heat or inappropriate sizing. In many cases, the worker stated that the chemical handling gloves were sized too big, making it difficult to handle bottle caps and nozzles. Cloth face coverings continued to be a common substitution for more appropriate respiratory protection. Other studies in Nigeria examine the use of a non-respirator "face mask" or "face covering" so perhaps more research is needed to determine the quality and use of non-respirator face coverings in Nigerian conditions to determine if they are protective or harmful (3, 7, 8).

Almost all agricultural workers stated that they often recycle or reuse agrochemical containers for in-home storage purposes, which seemed to be the case over a decade before the Norina Farms interviews were conducted (3, 4). More recently, in August 2021 a family of 24 individuals, including youth, deceased after consuming ground meal seasoned with fertilizer salt mistaken as food seasoning (9). Most workers also stated that agrochemicals were often stored in the home using unlabeled containers. Therefore, the storage container did not contain listed label ingredients—making it extremely difficult to identify first aid response or proper safety equipment as required by the label.

Future directions

The interviews conducted by Norina Farms found that agricultural families in Rivers State, Nigeria continue to encounter two major challenges for safe pesticides handling. First, these families have not had much experience using PPE and experience several barriers to obtaining safety equipment. Cloth face coverings continue to be used as a replacement for certified respirators and the same protective clothing is worn in the field and in the home. Only 2% of agricultural workers in the Norina farms interviews reporting using PPE, which was much lower when compared to other state in Nigeria. This highlights tremendous need for more community-based pesticides safety educational programs in this specific region. Second, improper agrochemical storage continues to harm agricultural families since many report reusing the containers for food storage purposes or storing other chemicals in improperly labeled containers. When compared to previous findings, the storage issue seems to be a long-standing problem.

Most pesticides safety training in Nigeria is retailer-based and focuses on larger contract sprayers (10). In this region of Nigeria, we believe that a community-based, grassroots-style pesticides safety program will be more effective than formal trainings focused on adult handlers only. This style of education would involve a family-oriented approach and should be amended for in-person presentation without internet access in rural areas. Even if agricultural workers cannot read or interpret pesticide labels, they should be able to recognize pesticides containers and have access peer-to-peer mentoring if they have questions. If future pesticides safety educational programs focus on raising awareness about proper pesticide labeling and PPE specifications, these agricultural producing families may become more empowered to advocate for PPE at their local agricultural supply store.

Author contributions

GU of Norina Farms is responsible for the conception of the article, community interviews, and pesticides safety trainings in Nigeria. JG assisted with the writing, organization, and formatting of this article for publication. All authors contributed to the article and approved the submitted version.

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Adolescence is an opportunity for farm injury prevention: A call for better age-based data disaggregation

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Introduction

Injury is a leading cause of mortality and injury-related morbidity, which can have lifelong impacts on physical and mental health, as well as on an individual's and family's economic livelihood (1).

Transport and unintentional injuries are the leading cause of death for adolescents 10–24 years of age, with more lives lost than communicable or non-communicable diseases, nutritional or maternal health causes or self-harm (2). Predominantly, in the injury prevention arena, there is a tendency to focus on young (especially under 5 years) children and therefore, despite the persistently high injury burden among adolescents, there has been limited research on, and evaluation of, the prevention of injury-related harms among adolescents (3).

Farm injury and its prevention

For adolescents, the farm environment poses a unique risk of injury as it is often a home, a workplace and a place for recreation with adolescents moving between these activities regularly (4). Farms are environments full of hazards such as noise (5), electricity (6), vehicles (7) including off-road motorcycles (8), quad-bikes (9) and utilities, agricultural machinery such as tractors and augers (10), as well as animals (11), plants and the broader environment. Additionally, living and working on farms exposes people to greater risk of injury from large farm animals including horses, as well as drowning risk due to unfenced natural water bodies (12).

In Australia, agriculture as an industry averages 82 non-intentional farm injury deaths per year between 2003 and 2006 (13). In New South Wales, Australia's most populous state, there was an average annual rate of 17.3 work-related deaths on farms per 100,000 people working in agriculture between 2001 and 2015 (14). With respect to hospitalized farm injury in Australia, between 2010–11 and 2014–15, there were a total of 21,999 farm injury related hospitalizations, with greater burden among males and in inner and outer regional areas (12).

Internationally, agriculture is one of the most dangerous industries in which to work and this is likely to increase with changes in climate, markets, transport systems and cost, staffing issues and farming practices (15). Evidence out of the United States of America indicates a child dies in an agriculture-related incident every 3 days, with transportation, machinery and contact with animals the leading mechanisms of injury (16). Agriculture has a wide range of hazards such as heavy machinery, chemicals and animals. In non-western countries, varying risks are present such as the risk of injury to toes and figures from hand tools for preadolescent agricultural workers in rural India (17).

Work in and around the farm often consists of tasks which over the course of a day can be extremely varied, each with their own risks. To address this in Australia the hierarchy of control, a framework of measures ranked on level of health and safety protection and reliability of control measures, is now embedded in legislation and provides a framework on which to address safety (18). A version of the hierarchy of control, as modified from Franklin and Scarr (19) can be found in Figure 1.

Farm injury risk can differ by age, with children and adolescents on farms having been identified as being at increased risk of injury (4). This injury risk arises as young people are often exposed to risks and hazards not normally present in a home environment and may have on-farm responsibilities which can lead to injury (4). Additionally, in Australia, a third of all child farm-related fatalities were among farm visitors (20). Such risks persist and, as such, fatal farm incidents among children <15 years in Australia have remained largely unchanged between 2001 and 2019, indicating a lack of progress on preventable deaths of children on farms (20).

Lack of age-based data disaggregation for adolescent farm injury in Australia

While Australia is fortunate to have regular and reliable data capture and collection of both fatal and non-fatal injury, including on farms, farm injury data on both deaths and hospitalizations are currently presented across two broad age bands: 0–14 years and 15+ years. Adolescence, which is defined as 10–24 years to reflect adolescent growth and popular understandings of this phase of life (21), therefore spans both age groups, making it difficult to derive age-specific injury risks for this cohort. This leads to the need for data disaggregation which involves separating collected information into smaller segments to discover useful trends and patterns.

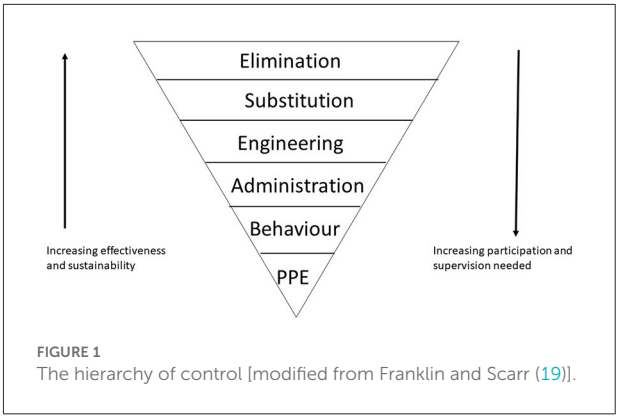

FIGURE 1
The hierarchy of control [modified from Franklin and Scarr (19)].

So why is age disaggregated data on farm injury-related mortality and morbidity necessary? The development of effective injury prevention interventions must be evidence-informed. This includes an understanding of how injury risk differs for different age groups. Leading injury control approaches, such as the Haddon's Matrix and the Public Health approach (22) include the identification of risk factors (such as age) to inform injury prevention efforts.

Generally speaking, injury does not occur among, or affect, different population subgroups in the same manner. In particular, injury risk for adolescents on farms is likely to differ significantly from young children and is likely to differ again from adults. Within reported farm injury-related fatalities for the 0–14 years age band in Australia, we see a concentration of drowning fatalities among children 0–4 years in farm dams, tanks and water troughs (20) the causal factors for which—low swimming ability, lack of adult supervision and barriers to water (23)—are unlikely to be of relevance to adolescents. Childhood farm injury mechanisms also include trail bikes, horse-related injuries and burns (9, 24, 25). By contrast, injuries related to the operation of farm machinery more often affect adult and older adult operators of such machinery who are injured while working (12, 14). However, quadbike injury risk is one that may span age—with adolescents likely to feature among quad bike injury statistics as both operator and passenger, and injury risk persisting into adulthood (14).

If undertaken in a developmentally appropriate way (26), the adolescent years represent an important opportunity to provide farm safety education with the goal of intervening to change behavior (27). This may be *via* the school system, as well as presenting an opportunity to provide education

to those who may not yet have been exposure to farm injury prevention information, either in their younger years or *via* their parents (28). With respect to farm injury prevention, adolescence is an optimal time to continue the safety conversation and can reinforce lessons from earlier years, which may then be applied as adolescents transition into the workforce (29).

To ensure the safety of adolescents on farms there is a need to ensure that the messages they receive are relevant, come from their peers and people they respect (including parents and people in positions of authority), are linked to the activities they are doing on farms, and are evidenced based (30). Safety information must also be followed up where possible with training (both informal and formal) and further activities with reinforce good safety practices, including legislation (30). Coaching is one approach that has been proposed to help with both improving safety practices, but also business practices more widely (31). Linking this to educational opportunities and a greater understanding of adolescent human factors would then help to nudge the culture toward being safer while also being productive (32, 33). School curriculum is one of the best avenues for providing training to adolescents (34). Developing and implementing interventions linked to curriculum standards have been proven to enhance their positive attitudes and result in higher intent to change their risky behavior (35). Universal health education on farming injury risk, rather than focusing simply on farming communities, is also warranted given a third of all child farm-related fatalities were among farm visitors, not farm residents (20).

Prior work to establish a prevention strategy for children in Australia has found that establishing a strong evidence base led to a tightly focused strategy (36). To inform the development of farm injury preventive interventions specific to adolescents, we call for improved data disaggregation to derive risk factors and evaluate injury prevention interventions specific to farm dwelling and working adolescents. Better data disaggregation on farm injury risk for adolescents will result in better understanding of the issue, including how risk varies by age, and therefore improved prevention interventions. A reversal in the neglect shown for adolescent injury prevention (2), including those injuries which occur on farms and in regional areas (37), would yield significant benefits, including the triple dividend (38) of reduced injury risk during adolescents, for adults working on farms and into the next generation of children living, working and recreating on farms.

Although there may be challenges around disaggregation of data in countries like Australia due to small sample sizes, this data could be made available upon request to those with approval to handle such sensitive data for the purposes of injury prevention. Another potential solution would be the reporting of disaggregated age group data for farm injuries over a greater period of time—i.e., 10 years or more to allow for more meaningful disaggregation while addressing sample size concerns. Similarly, a global repository of adolescent farm injury data would allow for secondary analysis of de-identified data and consistent reporting of age groups which varies widely for the adolescent age group (12, 13, 16).

In short, we firmly believe that sufficient disaggregation of age-based data enables more effective interventions and supports policies and strategies to address challenges in adolescent farm injury.

Author contributions

AP and RF conceptualized the study. AP wrote the first draft with assistance from RF. TT, DA, and CH critically revised the draft. All authors agree to be accountable for the content of the work. All authors contributed to the article and approved the submitted version.

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Perspectives from the UK: Children and agricultural health and safety

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Current situation

The United Kingdom of Great Britain and Northern Ireland (UK) is comprised of four devolved nations; England, Scotland, Northern Ireland and Wales. The regions have very different structures of agriculture. England has some of the largest farms in Europe, with an average size of 444 hectares and many holdings in excess of 20,000 hectares. By contrast Northern Ireland has some of the smallest farms in Western Europe with an average size of 32.4 hectares (1, 2). Common across the UK is that the majority of farms are family farms. While the extent of family labor on the farm is not statistically documented, quantitative research has consistently shown that family members, including children, are very involved and often the farm relies on this unpaid labor for its viability (3–5). Average figures for the UK obscure significant differences across the regions. Yellow Wellies, a UK based charity focused on farm safety, also known as the Farm Safety Foundation, note that farming is the most dangerous occupation in the UK. In Great Britain (England, Scotland and Wales) agriculture accounts for 1% of the working population but 18% of workplace fatalities. In Northern Ireland, the figures are 3.5% of the working population and 33% of workplace fatalities (www.yellowwellies.org). The Health and Safety Executive (HSE) in Great Britain gathers data on farm fatalities and the same function is carried out in Northern Ireland by the Health and Safety Executive Northern Ireland (HSENI). In Northern Ireland the HSENI recently brought together historical injury files and made 50 years of data available to researchers in the Agri-Food and Biosciences Institute and that data has been analyzed (A2, 4). This data is not available to the public. A recent Chief Executive of the HSENI was previously at the Department of Agriculture, Environment and Rural Affairs (DAERA) and brought an understanding of farm safety to the organization. There is a comprehensive farm safety partnership in Northern Ireland that includes the regional HSENI, DAERA, Ulster farmers unions and the Farm Safety Foundation (Yellow Wellies). They run a specific "be aware kids- child safety on farms" campaign. Their activities include a primary school (children under 12) farm safety campaign and an annual calendar competition related to farm safety. The Northern Ireland Farm Safety Partnership gathered data on fatalities for 2015 and 2019. This data is from periodical reports. The HSE in Great Britain has responsibility for promoting farm safety, including that of children. In Northern Ireland, while the statistical data is less available, safety measures seem better developed. The HSE data solely documents fatalities but not wounds and life changing injuries. Yellow Wellies have tried to fill this information gap.

For the purposes of this article children are defined as 0–18 years old. In Great Britain the Farm Safety Foundation run farm safety weeks with the HSE and highlight particular dangers to children and young people. The HSE Health and Safety toolbox (103 pages) has one mention of agriculture and this relates to infection and zoonoses. More recently it has produced a specific farm safety guide (56 pages) (6). In Great Britain, each farm fatality is described in a short paragraph.

Current challenges

The most significant challenge to improving health and safety on farms for young people is the peculiar nature of the farm. Children live and play at the worksite (7) and are immersed in the culture of farming from a young age. It is normal for children to play in the farmyard and to climb onto farm equipment. Another challenge is that despite awareness raising campaigns and safety manuals, people on farms are unaware or ignore the regulations around farming practice. A study in Scotland found that people interviewed did not know the legal age at which young people can operate machinery (5). A review of recent deaths recorded by the HSE details fatalities of children that were the result of negligent or illegal behavior. For example, in 2018/19 a 3 year old died after falling out of a farm vehicle and being crushed. It is illegal to have a 3 year old on a farm machine. A similar case of a 4 year old died in 2019/2020. In 2020/21 a 13 year old girl died when a quadbike overturned, she was not wearing a helmet contrary to HSE advice. There are many instances of such fatalities which happen annually. There is also a common myth within farming families that their children have a heightened sense of farm safety. This is despite the fact that almost all children killed on farms are farm family children. Research in Scotland found that women had this view that farm children have an innate sense of danger and understand how to be safe on farms. One woman interviewed said "*my son (three years old) wouldn't think about going out and running in front of a tractor or anything like that. Whereas he could have friends that come in that do silly things*." Farm families have a misguided idea that their children are born understanding the dangers of the farm despite evidence to the contrary (8).

One of the biggest cultural patterns to overcome is that farm family members normalize danger and socialize each other to take risks (9, 10). Children are socialized to undertake risky behavior. Danger is normalized within farming families. Parents are aware of the dangers of the farmyard. One mother interviewed by Zepeda and Kim in the United States said that "*I always pray every day that they make it to 18 years of age*" (2006: 116). No other occupation poses this level of risk to children. Research suggests that sometimes children and young people grow up in the environment and are blind to the risks of the farm and sometimes unsafe practices are passed on from parents to children (11). In the Scottish research, a woman recounted how her 3-year-old son rides on the tractor with his grandfather, but when they attended the main national agricultural show, he could not get on the equipment. Laughingly and deridingly she recounted; "*He couldn't understand why at the Highland Show*[1] *he couldn't get on the tractor to drive it! Because it's locked son! You can't get on! You can't get on it! Health and safety son!*"

Research in northern Ireland found that women who worked off farm worried about children coming home to empty houses, and they worried about children having to walk on dark country roads because school buses drop children a long way from the farm (4). One mother said "*there are more checks on calves than children.*" Research in Scotland (5) also found a mother who worried about leaving her small children in the house when doing farm work. Her partner worked off farm and she felt she had no other option but to leave the children alone.

Future directions

Currently the farmyard, despite being the most dangerous workplace, is very lightly regulated in the UK. Planning regulations and health and safety regulations make exemptions for agriculture that they do not for any other occupation, allowing it to persist as a dangerous occupation. In particular exemptions are made which allow younger children to drive farm machinery than is the norm for non-farm children. While young people cannot drive cars until they are seventeen years old, exceptions are made for farm children who are allowed to drive heavy machinery at thirteen and fourteen years of age as long as it is on the farm property, where the majority of injurie occur. The heredity nature of farming and the involvement of the family from a young age suggests that it is seen as a special, pre-industrial occupation to which rules do not apply as elsewhere. Hard questions need to be asked about why this hazardous occupation has so many exemptions from planning regulations and health and safety regulations.

The sanctions for failing to adhere to safe practice are light. The current loose regulatory framework around farm safety practice contributes to the view that farm danger is normal and what happens on the farm is beyond scrutiny. The UK does not need more information about the hazards faced by children on farms rather the challenge is changing farm family culture. Families ignore, or are unaware of, legal requirements. Health and Safety Executives, farm families and farming bodies must work closer together to ensure farms become safer places. Farm safety partnerships need

1 A large Scottish agricultural show.

to consider the type of support needed by farm families, such as where children are dropped by school buses and what type of childcare provision could be tailored for farm families.

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Looking at the gaps and program needs to address the impact on children of agricultural workers in Puerto Rico during and after public health emergencies

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Introduction

Hurricanes Irma and Maria in the Caribbean, wildfires in the western United States, flooding in parts of Pakistan, and extreme heat waves in Europe are examples of recent natural disasters that became public health emergencies. The consequences of these events, including access to essential services and damage and destruction of infrastructure, create a cascading impact, affecting the immediate and long-term health and well-being of the population. Intense climate-related events are projected to increase in intensity and impact (1). However, these do not affect everyone equally and vary depending on the characteristics of individuals, their work, ethnicity, residence, and language, among others (2, 3). Moreover, the social, economic, and political systems in which these events occur can function as either increase risk or foster protection.

In the case of agricultural workers, they are subject to various environmental stressors throughout their workday and experience greater risks than workers in most other industries (4). They are in a more vulnerable position regarding the effects that climate change may have on their work. Moreover, other psychosocial factors intrinsic to farming, such as social and working conditions, made agricultural workers one of the most affected populations during the COVID-19 pandemic (5). The physical effects that extreme events can have on the health of agricultural workers, and the damage and social effects of public health emergencies related to the climate crisis can also impact their children, especially those who are also part of the agricultural labor force. For minors who participate in agricultural work, the effect of disasters adds to the damage and general impact of high-risk exposures and lack of labor protection that are already of concern because of the effect on their health and development.

In addition to the characteristics and vulnerabilities of individuals, there are geographic regions where the risk and vulnerability to extreme climate-related is higher. This is the case of Puerto Rico, which has experienced several significant climate-related events in the past 10 years that caused millions of dollars in economic losses and the deaths of thousands of people. These catastrophic events have placed Puerto Rico first among the places most affected by the climate, according to the 2021 Global Climate Risk Index report (6). Beyond these climatic threats, this US territory faces economic and political challenges weakening potential protective factors during and after these disasters. This includes limited access to education and health services and essential infrastructures such as water, electricity, and communications. Housing and food security are also impacted. When considering these geographic, environmental, and political factors, as well as the socio-economic indicators of individuals, some populations are extremely vulnerable, which is the case of farming communities in Puerto Rico.

Castañer and the historic impact of disasters

Castañer, Puerto Rico, exemplifies an agricultural region that natural and public health disasters have greatly impacted. This mountainous farming community is in the west central region of Puerto Rico between the municipalities of Yauco, Lares, Adjuntas, and Maricao. The region is a key agricultural area due to a large amount of land and crops. The labor structure of the agricultural industry in Puerto Rico is extremely dynamic. Many families have small family farms or "fincas" and often the entire family, including the children, participate in its productivity in some fashion. At the same time, many of these workers are employed on larger, corporately owned farms. In 2012, the Castañer region had about 2,574 farms and 1,428 agricultural workers over 16 years of age (7, 8). The predominant crops include coffee, orange, banana, and plantain, mostly from small or family farms. More than 50% of people in this region are below the federal poverty level, 95% are Hispanic/Latino, and the average age is between 42 and 44 years (8). The area is no stranger to catastrophes, such as Hurricane Maria in 2017 and Hurricane Fiona in 2022, that have significatively affected the island. These natural events add additional stress factors to a major economic and migratory crisis Puerto Rico has been experiencing for over a decade. Castañer is highly susceptible to landslides and is among the regions that reported more than 25 landslides per square kilometer during Hurricane Maria. About 74 residential areas were marked as flooding risk (9, 10). Fiona was a category one hurricane that left over 30 inches of rain in some regions in 72 h period, significantly impacting agriculture, the stability of the education system, electricity, and services (11). Additional public health concerns have been documented due to this hurricane, including lack of safe water, increased risk factors for respiratory or cardiovascular diseases, and exposure to infectious diseases such as leptospirosis (12, 13).

In understanding the impact of public health emergencies on the children of agricultural workers, Castañer offers an important example of compounding and cascading events that affected this population. Climate-related disasters and the COVID-19 pandemic impacted the health and well-being of children. The livelihoods of agricultural families were affected due to substantial crop loss, destroyed or damaged homes, lack of resources, food insecurity, and interrupted education. When looking at the profile of children in Puerto Rico, about 57% of children live below the federal poverty level and an estimated 23% are likely to suffer from food insecurity (14, 15). The amount is substantially greater in the Castañer region, reaching between 60 and 82% of children living in poverty (14). There is one federally qualified community health center that offers services to nearly 11,279 patients in the region. Of those patients, 24% are under 18 years of age, 95% are below the poverty level, and 25% are identified as farmers and dependents of farmers (16). Prevalent childhood health conditions in the region include asthma and obesity (17, 18). In terms of educational services, this region has faced the closure or relocation of schools, which reduces immediate access to education and other associated services such as meals. In a region with a school desertion rate that can be as high as 6% compared to 2.9% for the territory, this presents a major threat to the social and economic mobility of the region (19). Furthermore, traveling distance to the nearest schools can take more than 30 min in these mountainous areas, which represents a significant burden for a population with such high levels of poverty. These social and environmental spheres must be considered when we analyze the impact of public health emergencies in the region, such as COVID-19.

During the beginning of the COVID-19 pandemic in 2020, schools in Puerto Rico and other related services were shut down for several months. In August 2020, the Puerto Rico Department of Education implemented remote learning, requiring access to internet services, consistent electricity service, and access to computers. Several reports document the exacerbated situation that students in rural areas experienced regarding education, including low turnout or students not reporting to classes due to limitations in technology, as well as challenges of parents finding childcare during work hours. As a sphere of social protection, the absence of school services, in turn, implied limitations in food security and physical security. During this period, Puerto Rico registered increased maltreatment due to negligence (20). The in-person return to class in Puerto Rico was driven by the observation that the state educational system had struggled to reach some rural populations and that these areas were at a substantial disadvantage in terms of academic achievement. However, the in-person return in the Castañer region was affected by several factors, including schools under repair due to Hurricane Maria or the southern earthquakes, schools closed for economic reasons, and/or levels

TABLE 1 Characteristics and living conditions of children in agricultural communities in Puerto Rico before, during, and after emergencies.

Emergencies/Disasters history	Puerto Rico experienced five major disasters and emergencies in the last 5 years, including 2017 Hurricanes Irma and María, 2019–20 Southeast earthquakes. 2020–22 COVID-19, 2022 Drought, and 2022 Hurricane Fiona.
	Impact on agricultural regions flooding and landslides was from significant to catastrophic.
Conditions of one agricultural community in Puerto Rico	The island has a fragile utilities infrastructure (water, power, communications, roads).
	60–82% children in one agricultural region live in poverty
	Limited access to schools due to planned closures.
	One community health center and three vaccination sites.
Outcomes	Children in the region experienced limited access to healthcare and 5 years of interrupted/limited education.
	Food, economic, and physical security was impacted.
	Exposure to infectious diseases including COVID-19 and leptopirosis.

of transmission of COVID-19 reported for the region. Schools in this region reported a significant number of outbreaks and a high percentage of positivity of COVID-19 cases among students (21). The region had limited vaccination and testing services, with three vaccination centers and one center for testing or free medical care for the pediatric population.

Discussion

Even though there are reports documenting the impact of public health emergencies in Puerto Rico, very few explore vulnerable populations such as agricultural communities. This contrasts with recovery efforts aiming at maximizing agricultural production and social development and mobilization in rural areas. For Castañer, while a large part of the population participates in the agricultural industry, the response and recovery initiatives are falling short of improving social conditions. Although there are no specific studies examining the impact of these emergencies on agricultural worker children in Puerto Rico, given the described poverty levels and education limitations, it is highly likely that they have been greatly impacted by recent public health emergencies. We explored various publications and statistical reports to understand what the social and environmental conditions of children of agricultural communities are following 5 years of continuous emergencies and disasters. Table 1 presents the overall findings for the Castañer region. The lack of data on the impact of climate and public health emergencies on minors who are part of the agricultural community limits the implementation of programs that support their development and promote their social mobility while protecting their health.

Conclusion

Understanding the needs of children in agricultural families, as well as exploring the impact of the social spheres that may affect their well-being, is crucial to developing and adapting programs that target their health and safety. Assessing the impact of emergencies on children's health is especially essential for regions like Puerto Rico, with a higher risk of natural disasters and more intense disasters due to the climate crisis. Puerto Rico, its agricultural communities and the children in these regions should be prioritized.

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Childcare for farm families: A key strategy to keep children safe yet largely absent from farm programming

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Despite long-standing safety recommendations that non-working children be supervised off the worksite by an adult, little is known about farm families' ability to comply. We conducted a review of 92 documents and 36 key informant interviews in three U.S. states (Ohio, Vermont, and Wisconsin) to assess how farm service providers and farm organizations address the intersection of children and childcare with farm work and farm safety in programming. Through their programming, these two groups deeply influence farm families' social systems, affecting farm safety and farm business decisions. Study design and result interpretations were grounded in the women in agriculture literature, which examines the needs and realities of farm women (often the primary caregivers). Most documents reviewed did not address children, and even fewer addressed childcare. Interviews confirm findings of the document review. Despite awareness that farm families juggle work and children, few interviewees explicitly integrated children and childcare topics due to a messy and complex set of individual- and structural-level factors. We identified four possible, overlapping explanations for this tension: valuation of care vs. farm work; farm programming's traditional emphasis on the farm business; alignment of the programming with the agrarian ideal of the family farm; and the mismatch between farm programming scope, resources available, and childcare challenges. We conclude with two main implications for farm safety programs and farm children safety. First, farm programming's reinforcement of the social and cultural expectations regarding children's involvement in the farm operation from a young age could be counterproductive from a farm safety standpoint and miss an opportunity to provide alternative models of childrearing. Second, the invisibility of the lived realities of raising children may lead farm parents to distrust farm programming and deter them from participating.

KEYWORDS

farm business, farm safety, children, childcare, farm programs and resources, farm organizations, farm women

Introduction

Farm safety researchers and educators have worked for decades to reduce the high rates of injuries and fatalities experienced by farm children. Despite the progress made as a result of these efforts, some have argued that injuries and fatalities rates remain too high, in particular among by-standing non-working children (1, 2). One explanation is the regulatory framework where no laws prevent farm parents from involving their children in the farm or the existing laws are deemed insufficient and/or not enforced (3–5). Another explanation is the low uptake of recommended safety strategies by farm parents (6–8). A key strategy to limit risk exposure for non-working by-standing children is the supervision of children by a dedicated adult off the worksite (hereafter "childcare," whether paid or unpaid) (9–12). Yet, research has found that farm parents in a range of countries continue to bring their children to the worksite even when aware of the risks (13–16).

Currently, research has provided insights into farm parents' and farm children's safety knowledge and behaviors (17–19), as well as the cultural and social motivations behind why farm parents bring their children to the worksite (13–15, 20). However, despite decades of farm safety interventions to encourage farm parents to limit farm children's access to the worksite, there exists a dearth of research on childcare in agriculture. We know of only four peer-reviewed studies on childcare and farm safety, all from the U.S. and all based on small sample sizes. Three focused on migrant farm worker parents (21–23), and one focused on farm owners/operators (24). Findings from Gallagher (1) and Hartling et al. (25) indicate insufficient research has assessed the efficacy of farm safety interventions aimed at improving the safety outcomes of non-working by-standing children, further underscoring the need to probe more deeply into the reasons that shape farm parents' use of childcare.

Outside the farm safety scholarship, research examining the persistence of family farms (i.e., their ability to stay on the land despite on-going changes) has found that access to affordable quality childcare is a common challenge among farm families in the U.S. and directly affects farm enterprise development along with farm family and farmworker relationships (26, 27). Meanwhile studies on women in agriculture in Germany (28), Nigeria (29), Scotland (30), Switzerland (31, 32), and the U.S. (33–35) have pointed to women's challenges in taking care of the children and to the lack of support. Such childcare challenges in the context of farm business indicate a need for expanding farm safety research by looking at how larger systemic and structural issues shape farm parents' safety decisions along with their children's safety outcomes. These questions are particularly essential to answer since COVID-19 both likely increased the presence of children on farms (24, 36) and heightened existing challenges in the childcare sector in the United States (37) and also in countries with traditionally stronger supports for families such as France (38), the United Kingdom (39), and Australia (40, 41). These questions also connect to the call from Lee et al. (42) to shift away from a focus on individual-level factors by adopting a systems approach that deepens our understanding of farm children safety outcomes.

In this article, we contribute to the understanding of farm parents' safety decisions by assessing how farm service providers and farm organizations address the intersection of children and childcare with farm work and farm safety in their programs and resources. Part of a larger research project to understand the links between childcare and farm children safety (43), our rationale is grounded in the Socio-ecological model (SEM) and thus first focuses on the larger environment before turning our attention to farm parents. The SEM, a well-established framework in the fields of human development and public health, examines the complex social systems in which individuals are embedded (also referred to as spheres of influence), and the ways in which individual's behaviors are shaped by these social systems (44, 45). Both farm service providers and farm organizations create and deliver programs, a key function within, and strong influence over, a farm family's social systems, business, and dynamics (42). It is therefore critical to assess how those providing technical assistance and how those representing the interests of farmers to a range of stakeholders understand and approach topics connected to children and childcare if we are to understand the safety decisions that farm parents make. Through a document review of 92 farm programs and resources identified through an environmental scan and 36 interviews with farm safety and business service providers along with farm organization representatives in three U.S. states (Ohio, Vermont, and Wisconsin), we answer the following research questions: (1) How do farm service providers and farm organizations integrate topics connected to children and childcare in their programming? (2) What are farm service providers and farm organizations' perspectives on the interactions between children, farm business, and farm safety? and (3) What factors shape the integration of children and childcare topics in programs and resources? Farm programs and resources (hereafter farm programming) include the tangible and non-tangible educational outreach developed and/or deployed by farm service providers and farm organizations which include, for example, fact sheets, articles, tools, workshops, trainings, one-on-one service delivery, and initiatives. We consider children and childcare to be comprehensive of both the population of focus and activities connected to caring for that population of focus.

Given the farm safety knowledge gaps around childcare use, and given that women continue to play a primary role in caring for the children including in agriculture (27, 46, 47), we grounded our research design and interpretation of the findings in the women in agriculture literature [for reviews of the literature see: Ball (47), Brandth (48), Dunne et al.

(49, 50)]. In particular, we draw on a line of research on farm programming and the representation of women in farm organization in Western industrialized countries which, for the English-language literature, is largely from Australia, the U.K., and the U.S. Despite variations in the social, cultural, political, and economic systems across these countries, this body of work provides similar key insights around the inclusion of women's needs and lived realities in farm programs and farm organizations. In addition, this body of work provides sociological insights around gender roles and division of labor, recognition and valuation of different types of work (i.e., care work, house work, farm work), and the reproduction of social norms and structures. See for example Shortall (51), Shortall (52), Shortall and Adesugba (53), Pini (54), Liepins and Schick (55), Alston (56), Alston (57), Trauger et al. (58), Trauger et al. (59) whose work we will discuss further when interpreting our findings.

Our article contributes to the farm safety literature by expanding the field in at least two ways. First, we move beyond the current focus on the individual-level factors that shape farm safety decisions by foregrounding the contexts in which these decisions are made. Recognizing that farm parents are informed by a complex landscape of farm programs, we consider the programming from farm business service providers and farm organizations which is an important expansion of the farm safety evaluation research that has traditionally focused on farm safety programs [see for example: Gallagher (1), Rautiainen et al. (60)]. Second, we bridge the farm safety literature and the women in agriculture literature which, despite many overlapping focal themes, have largely remained siloed. The farm safety field has recently called on the need to consider the specific needs women (61) and the interactions between farm children safety and farmwomen wellbeing (24). Developed by rural social scientists around the world starting in the 1970s−1980s, the women in agriculture literature provides an extensive body of knowledge around the social, economic, and cultural conditions of farm women; all key to understanding farm family dynamics, farm safety and wellbeing outcomes.

Methods and analytical strategy

We used a two-steps mixed-methods research design to answer our research questions. First, we draw on secondary data from an environmental scan of publicly available farm programming. Second, we draw on primary data from key informant interviews. From a methodological standpoint, the merging of these two approaches, which we describe in detail below, enables the development of broad and nuanced insights to answer the research questions (62, 63). Furthermore, the triangulation of data of different types and sources is an important strategy to assess the validity of the findings (62, 64, 65). From a conceptual standpoint, our merging of public material and original interview data was informed by Liepins and Schick (55), who proposed a framework to critically analyze agricultural training as it pertains to meeting the need of women in agriculture. Expanding on the work of Shortall (51) who had drawn on the sociology of education and drawing on Foucault (66), a prominent scholar of power and knowledge, Liepins and Schick (55) argue that an analysis of farm programming content and the discourse around that content provides key insight around whose needs are served, what and whose knowledge is seen as legitimate, and who holds power in society.

As part of a larger research project, the three study states (Ohio, Vermont, and Wisconsin) were selected to capture: (1) the family farm model, a historically prominent farm structure in the Midwest and Northeast (67), (2) variations in farm commodity and scale (dairy in WI and VT of different sizes, large commodity crop production in OH, and smaller diversified operations in VT) (68), (3) variations in childcare environments with VT providing an extreme (or deviant) case study site (63) due to the state's significant investments in early childhood education prior to COVID-19 (69, 70). In addition, researchers had existing professional networks in these states along with on-the-ground knowledge of the agricultural sectors. The environmental scan is based on publically available secondary data and did not require a review by our Institutional Review Boards (IRBs). The IRBs determined the key informant interviews exempt from review.

Document review of farm programming

We collected the farm programming material through an online environmental scan conducted between November 30 and December 21, 2020. We used a set of search terms including "farm safety," "beginning farmer," "young farmer," and "women in agriculture" in combination with the names of our study states "Ohio," "Vermont," "Wisconsin." While farm safety is an important aspect of this research, we used the three other search terms to identify the broad range of farm programming that are likely to reach families with younger children. This approach is in line with the SEM to understand the landscape of institutional organizations in which farm parents make decisions connected to their children (42, 44, 45). Because our focus was on understanding how prevalent topics related to farm children and childcare are within the broad range of programming targeted at farmers, we did not include "children" and "childcare" as initial search terms. We used two search engines to reduce search bias and increase reliability: Google and DuckDuckGo (a search engine that does not customize results based on previous searches) and conducted the searches until reaching saturation (i.e., no new relevant programming were found). We screened the 194 identified search findings and removed 102 that were either duplicates or non-relevant

programs/resources (i.e., non-U.S. programs, previous events). The searches were originally focused geographically on our three study states. However, our search led to the identification of regional and national programming and we elected to retain these search results since their programming are accessible to farmers in our study states. We recorded the following information into a spreadsheet for each of the 92 remaining search findings: organization and program/resource name; search type (i.e., which keyword led to the identification of the program/resource); geographical area of focus (i.e., OH, VT, WI, national, regional); and contact information for key informant interviews recruitment. We also saved PDFs of programming (i.e., we electronically printed relevant sections of websites and downloaded relevant attachments found on websites).

We conducted two rounds of data coding and analysis on the 92 search results. First, we reviewed each of the search results and categorized them using a codebook developed based on the study goals and observations of the search results. There sets of codes were applied to both text and pictures. The first set of codes documents whether the resource/program targets a specific population of farmers (i.e., young farmers, beginning farmers, women farmers, farm employers) based on a yes (1)/no (0) scoring. The second set of codes determines the focus of the program (i.e., farm business, farm safety, balancing work/life), also based on a yes (1)/no (0) scoring. The third set of codes asked to what extent children/family and childcare aspects are incorporated into the farm programming based on a 3-point ranking to document the offering's continuum: (1) No mention; (2) Inconsequential mentions for material with broad statements and/or pictures but no practical information or resources. Examples of inconsequential mentions include a statement about the value of raising children on the farm or a statement about the importance of keeping children safe; and (3) Integrated in programming for content with practical guidance or resources to navigate children on the farm and/or to ease childcare access. Examples of integrated programming include a farm business planning worksheet with a section on the role of all household members including childcare duties, childcare/school expenses line in a budget tool, or advice to consider family needs and community amenities when purchasing farmland.

We conducted univariate analysis to assess the frequency of each code. In the second round of data coding and analysis, we qualitatively assessed the content of the programming by taking notes on our observations of text and pictures. We focused on describing the incorporation of children/family and childcare into the material across the three main program/resource focus (i.e., farm business, farm safety, balancing work/life). We then reviewed and summarized the content of these notes. Since we reviewed the material from most organizations included in our key informants sample, this article does not include visual examples (e.g., screen shots) in order to preserve the anonymity of the interviewees per our IRB protocol.

Key informant interviews

Key informants included farm safety service providers, farm business service providers, and representatives of farm organizations. We identified these informants through: (1) project advisory board recommendations, (2) collated list of organizations and contact information identified through the document review, (3) the research team members' professional networks, and (4) a snowball sampling approach wherein we asked interviewees about other informants to interview (63). The goal of this multi-pronged approach was two-fold. The first was to limit selection bias by identifying interviewees through several avenues. The second goal was ensure a large enough list of potential interviewees to reach our target of 30 informants (10 per study states), a commonly accepted threshold to reach saturation (71–73). Our list of 85 potential interviewees included, among others, U.S. Department of Agriculture (USDA) young and beginning farmers' state coordinators, state departments of agriculture, University extension educators, and farm organizations. Out of the 60 individuals contacted, we interviewed 36. Seven declined to be interviewed most often citing that their programming does not incorporate children or childcare.

Key informants were interviewed with a semi-structured interview guide with branching questions that touched on five themes: (1) background information, (2) coverage of family, children, childcare topics, (3) childcare service offerings during programming, (4) childcare arrangements of the farm families they serve, and (5) the landscape of childcare in their geographical area. The branching questions were targeted to key informants working either on farm safety topics or farm business topics. To refine the interview guide's clarity, completeness, and flow, we sought feedback from the six-person project advisory board, comprised of a farm organization representative, a federal agency employee, professionals who work in farm business and farm safety topics, and a child development researcher—half of whom also operate a farm. We piloted the interview guide with two individuals in similar roles as targeted informants but outside of our study area, and revised the guide based on feedback. We conducted the interviews through the video conferencing platform, Zoom, and used the cloud recording function to generate auto-transcripts. Interviews lasted on average 52 min, ranging from 27 min to 1.4 h. A research assistant reviewed transcripts to ensure completeness and accuracy and to anonymize them.

Our final sample included 36 key informants across the three study states. On average, interviewed individuals were 46.7 years old, 83% of them were female, and 72% had direct personal connection to agriculture by growing up on a farm and/or working on a farm as an adult. Half of the respondents had a master's degree while over a third had a bachelor's degree and 14% had a doctoral degree. Looking at interviewees' organizational affiliation and focus area, over half

TABLE 1 Characteristics of interviewees ($n = 36$).

	n	Proportion
Average age in years	46.7	
Gender		
Female	30	83.3%
Male	6	16.7%
Personal connection to agriculture[a]		
Direct	26	72.2%
Indirect	4	11.1%
No	6	16.7%
Educational attainment		
Bachelors	12	33.3%
Masters	18	50.0%
PhD	5	13.9%
Other	1	2.8%
Organizational affiliations and focus areas		
Farm safety service provider	8	22.2%
Farm business service provider	20	55.6%
Farm organization	8	22.2%
State of residence		
Ohio	11	30.6%
Vermont	12	33.3%
Wisconsin	13	36.1%

[a]A direct connection to agriculture is when people reported having grown up on farms and/or having done farm work at one point or another. An indirect connection to agriculture is when people indicated a family background such as grand-parents operating a farm but no clear direct involvement in farm work.

(56%) were farm business service providers in organizations, while respectively 22% were farm safety service providers and from farm organizations. Given the limited number of potential interviewees in some organizational affiliations, we created categories that capture both the focus of the interviewee's work and their organizational affiliation to limit breach of confidentiality. Furthermore, these categories were productive to identify patterns in the data. The service provider categories included outreach professional and researchers with an outreach appointment in university cooperative extension services, non-profit organizations, or state or federal-level government agencies. Farm organizations are membership-based organizations that cover a broad range of farm-related activities. Last interviewees' state of residence was split almost evenly between Wisconsin (36%), Vermont (33%), and Ohio (31%). See Table 1 for interviewee's characteristics.

We used a directed content analysis approach (74, 75), an iterative approach to qualitative data coding and analysis that includes deductive and inductive codes. The deductive codes were based on the interview guide questions (i.e., structural codes). The following is an example of a structural code group "Coverage of children/family and childcare aspects in programming" with the following sub-codes "Programing offered," "No programming offered," "Children/childcare programming," "Farm parents' engagement," and "COVID-19 related changes." The inductive codes covered aspects of the data not covered through the structural codes but connected to the larger research aims and arising from the data (i.e., content codes). The following is an example of content code group "Children on farms" with the sub-groups "Intersection of children with farm business," and "Intersection of children with farm safety." The first and third authors coded and analyzed the data using the NVivo software (QSR International, Burlington, MA). To refine the codebook and to ensure consistency in use, we coded the same transcript, then used the Kappa co-efficient to discuss necessary codebook changes and coding approaches variations. We repeated this iterative process of two people coding the same transcript and addressing differences one time which is when we reached: (1) the average Kappa score of 75% across all codes, the threshold for excellent agreement (76) and (2) we were satisfied with usability and coverage of the codebook. We then split the remaining transcripts between the two coders and met on a regular basis to discuss potential adjustments to the codebook along with emerging themes and patterns. Upon completion of coding, the first author extracted and conducted a thematic analysis of the content of all codes related to the guiding research. The first and third authors regularly conferred to ensure identified themes and patterns were reasonable conclusions to draw from this body of data. Specific analytic attention was given to identify the range of responses and patterns in how these responses varied across main focus of program areas, organizational affiliations, and geography. The thematic analysis revealed organizational affiliation to be a more important factor than geography in explaining whether participants included childcare in their programming. The relatively small number of farm organizations in each state also makes maintaining anonymity more difficult when reporting state-specific findings. For both of these reasons, results do not name participants' states. To support the process of triangulation, we present the findings of the document review and key informant interviews together.

Results

Limited coverage of children and childcare topics in farm programming

The document review provides an overview of the integration of topics connected to children and childcare in farm programming. Out of the 92 program materials we analyzed, 53% made no mention of children/family topics and 83% made no mention of childcare. Almost one-third (29%) of the material reviewed included an inconsequential mention of children/family aspects and 12% of programming

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TABLE 2 Coverage of children/family and childcare aspects in farm programming ($n = 92$).

	Children/family aspects			Childcare aspects		
	No mention	Inconsequential mention	Integrated in programming	No mention	Inconsequential mention	Integrated in programming
All material reviewed	53%	29%	18%	83%	12%	4%
Variations by target population						
Young farmers	45%	27%	27%	82%	9%	9%
Farm employers	15%	31%	54%	62%	23%	15%
Women farmers	54%	31%	15%	85%	8%	8%
Beginning farmers	61%	29%	10%	88%	7%	5%
Variations by primary focus						
Work life balance	20%	50%	30%	60%	20%	20%
Farm safety	30%	30%	40%	70%	21%	9%
Farm business	65%	29%	7%	92%	5%	3%

included inconsequential mentions of childcare (Table 2). Common examples of inconsequential mentions included pictures of smiling families with young children, statements about the value of raising children on the farm, or a statement about the importance of supervising children off the worksite to keep them safe. Last, 18% of the reviewed material integrated children/family in their programming while 4% of programming integrated childcare-related aspects. Two examples of the integration into programming included one business planning worksheet with a section inviting farmers to list the role of all family members including who is looking after the children plus an article outlining strategies to identify childcare (paid and unpaid).

We found variations of coverage based on intended target audiences. Almost half (47%) of the material targeted beginning farmers, followed by women farmers (29%), farm employers (14%), and young farmers (12%) (defined by the USDA as those under the age of 35). Meanwhile, 16% of the material did not target one of these target audience. The material targeted to farm employers was most likely to touch on children/family and childcare aspects: respectively 85 and 38% made at least an inconsequential mention of these aspects. The material targeted to beginning farmers was the least likely to touch on these aspects as respectively 39 and 12% made at least an inconsequential mention of children/family and childcare aspects.

Looking at the primary focus of the programming, 67% of the material reviewed was primarily focused on the farm business (i.e., farm financials, farm production, and land access), 37% on farm safety for children and adults, 11% on work/life balance (i.e., mental health and family relationships), and 11% on other topics (i.e., leadership skills, advocacy, and networking). An inconsequential mention or better was most likely to be made by materials which focused on work-life balance. We found that 80% of these materials made at least an inconsequential mention on children/family and 40% of them made at least such a mention of childcare topics. On the other hand, programming material focused on the farm business were the least likely to touch on children/family or childcare, at 36% and 8%, respectively, making an inconsequential mention or better.

The key informant findings align with those of the document review in the sense that informants reported limited coverage of children and childcare topics in their programming. Furthermore, we found variations in the level of coverage based on the organizational affiliation and focus of the three groups of interviewees: farm safety service providers (22% of interviewees), farm business service providers (56%), and farm organizations (22%). Farm safety service providers were the most likely to integrate topics connected to children and childcare in their programming with recommendations and trainings targeted to farm parents, youth, and employers. Most of the integration was for children-related topics with the provision of information about children's exposure to risk and the provision of practical guidance to remediate these risks. Examples of practical guidance included designing safe play areas on the farm, the safe operation of machinery (e.g., ATVs, tractors), and the assignments and supervision of age appropriate tasks. The coverage of childcare topics by farm safety service providers was largely inconsequential. While most of these interviewees talked about the importance of childcare to keep the children safe, none provided practical guidance that would support use of childcare such as how to identify childcare and financial support to pay for childcare.

Farm business service providers were the least likely to integrate children and childcare into their programming. However, the coverage significantly varied across the different program areas, if information was integrated either formally

or informally, and varied across the organizational structure farm service providers are embedded in. Programs for beginning farmers and farm management programs commonly wove in children and childcare topics when deemed relevant, but did not present on these issues as stand-alone topics. For example, a program might invite farmers to reflect on family goals and values alongside setting farm goals, or invite participants to include household-level needs when budgeting health insurance, childcare, and school costs and determining roles on and off the farm. A few interviewees emphasized how they bring up children in informal discussions particularly when working with beginning farmers, both to set realistic expectations and to deflate what they felt are over-romanticized expectations of raising children on the farm. Interviewees focusing on women in agriculture and farm transitions programs were the least likely to touch on children and childcare topics. When they did, it was indirectly through programming on family relationships, communication, and managing households.

The ways in which interviewees working for farm organizations touched on children and childcare through the lenses of farm business, farm safety, and quality of life varied considerably and fell along a spectrum ranging from minimal and informal discussions to intentional and formal programming. Interviewees on one end of the continuum reported that the farm organization they represented did not explicitly integrate children and childcare topics in their programming. At the same time, these interviewees spoke to the importance of family farms to their membership-base and to having a thread of family issues running through their work. For example, interviewees talked about creating a family-friendly space with children at events while another talked about conferences where family relationships and business might intertwine. Further along the continuum, interviewees talked about the explicit integration of these topics through blog posts, conference sessions, and virtual focus groups. Their emphasis was on immediate support to farmers through peer-to-peer sharing of stories and resources while also normalizing discussions about the challenges of raising children on farms. For example, one interviewee talked about bringing up household expenses such as childcare and health insurance in discussions about farm budgets because she finds that farmers do not bring up the topic on their own. At the other end of the continuum, some interviewees talked about the need for long-term solutions and the need to explicitly integrate children and childcare topics through their advocacy work and coalition building with childcare advocacy groups. These interviewees described a range of specific policy solutions such as universal childcare, and curriculum solutions such as farm service provider training to encourage and enable programing that would include information about existing resources to help farmers access childcare.

Finally, a consistent finding among key informants who actively integrated children and childcare topics was that they were already doing so before COVID-19. Still, the pandemic reinforced the need for this work. For those not integrating children and childcare topics, some interviewees shared they had become more aware of the challenges faced by parents as a result of COVID-19. We note the interviews were conducted in the early months of the pandemic and the extent to which future programming has emerged or will emerge is uncertain. Indeed, when asked about whether the interviewees' organizations were currently or planning to develop programs, resources, or policies to incorporate children or childcare in their programming, 80% said that they were not.

Nuanced and layered set of perspectives on how children interact with farm business, farm safety, and parents' wellbeing

Despite the limited formal integration of children and childcare topics into programming, this sample of key informants provide a nuanced and layered set of perspectives of how having children on the farm interacts with the farm business and farm safety. It ought to be noted, however, that many of the reflections indicative of this nuanced and layered set of perspectives took time to emerge in the interview and occurred despite some informants indicating that they were not sure if they should participate in the interviews given that their programming did not cover children and childcare topics. Furthermore, some key informants stated that the interview questions allowed them to reflect on these issues and make connections they had not previously explicitly realized. For example, a farm business service provider said "*I mean until we had this conversation now, and never really, honestly it's interesting to think about it*" (interviewee #9) and a farm safety service provider shared "*I mean just having this conversation today will make me think about well, what do parents who have a child that want to come to a program do?*" (interviewee #5).

Reflecting on the interactions with the farm business, interviewees spoke about the day-to-day impacts children have on the farm, and how children can dictate what and how much work can be done. Interviewees honed in on how children slow work down and the need to find ways to keep children busy as illustrated by a farm organization representative "*When I talked to two farmers who are parents, you know, they can work so much more quickly without three little kids following them around to do everything*" (interviewee #27) and reinforced by a farm business service provider "*Your productivity is definitely going to be less I think. It's just a balancing act of what you need to get done, and it is affecting your income to the point where it offsets paying for childcare*" (interviewee #7). Interviewees also talked about the mid- to long-term impact of children, sharing stories of farmers making changes to their business structure,

market channels, labor allocation, and growth plans in order to adapt to children. For example, a farm business service provider shared the experience of one farm family: "*he's got five kids and he watches those five kids all day plus milks cows twice a day, and he went for a while there he went down to milking once a day that way he could even take care of the kids easier*" (interviewee #33) and another farm business service provider shared "*For children that are very young in a lot of cases what you will see where one of the parents kind of pulls back a little bit from the farm business to do a little more of that childcare if they can you know again that's a sacrifice to the business and can be hard*" (interviewee #26). The document review and some of the key informants pointed to the social and cultural expectations that farm children spend time on the farm with their parents. For example in the document review, this was seen with the smiling pictures of children with their parents in the worksite along with statements around the benefits of raising children on the farm. Interviewees discussed how they navigate these social and cultural expectations, at times willingly at times unwillingly, through their programming. Farm safety service providers in particular have the added challenge of needing to navigate push back from the farm sector when farm safety recommendations may be perceived as going against farm parents' ability to integrate their children in the farm operation. This farm safety service provider spoke to some of that tension: "*We are mandated to train and certify 12 year-old children to be able to drive tractors and operate machinery. That's if you're going to work for a non-family farm. It goes directly against the NAGCAT guidelines, or the child safety guidelines, especially at age 12. I know it depends on the horsepower of the tractor and stuff like that. There are disconnects from things that are happening here in the state, what we are legally being not only allowed to do but made to do in terms of certifying those kids that really don't qualify if you follow those guidelines directly. Ethically that's challenged me*" (interviewee #28).

Farm safety interviewees frequently pointed to children's habitual presence on the farm and the implications for the children's safety. A farm business service provider stated "*You are probably going to want at some point in your parenting career rely on external childcare of some shape or form because there's going to be some times, where you have to give your business your undivided attention, and it would just be too distracting or dangerous to have especially really young kinds on the farm*" (interviewee #14). Interviewees, across focus areas either explicitly or implicitly hinted at the complex balancing act farm parents face between the work that needs to get done, the danger children are exposed to, the farm safety recommendations, and the childcare options. For example, a farm organization representative said: *"The world could go through a pandemic, and suddenly your kids are all home, and you're expected to not only keep the dairy farm going or the veggie farm going, but you're also expected to homeschool and keep your kids safe, and there's no one else to help you, and yeah, it's a pretty—it's been a pretty startling reality, and obviously, this last year has been extreme circumstances, but as so many people have said, it's shown the glaring holes in the social safety nets that we have for so, so many people*" (interviewee #16). Interviewees described the strategies farm parents use to reconcile the competing need to get farm work done while keeping their children safe. Specific practices that key informants shared included: teaching children safety, completing the most dangerous tasks based on who is available to look after the children or when children are occupied, slowing down the work to make sure children do not get into something dangerous, teaching children safety, and giving them age-appropriate tasks.

Two overlapping but distinct paradigms among the majority of interviewees were used to explain why farm parents expose their children to risk. The knowledge-deficit paradigm was dominant especially among farm safety service providers. Some of these interviewees talked about the lack or inadequate awareness of farm parents to dangers, in particular among older generations, and the importance of educational programming to remediate the lack of knowledge. A farm safety service provider illustrates this paradigm: "*And in all fairness, part of my experience with them [farmers] is that some of them are simply not aware of the dangers and aware of how truly dangerous this is. I know that even for myself before I started my job that I'm in I didn't realize just how dangerous being a farmer could be and how dangerous that work site is*" (interviewee #29). In contrast, farm business service providers and farm organization key informants were less likely to see farmers as not knowing. Rather, they were more likely to approach the topic from a material-deficit paradigm, where parents are aware of the dangers but that the farm safety recommendations, in particular of keeping children away from the worksite, are either not practical or not feasible largely due to childcare challenges. A farm business service provider explained: "*Yeah I think even with farm safety, and that might be questioned you've got coming up too, is they just don't have another option out there. As far as you know well the kids have to be with me because there isn't no other option, nobody else to watch them so they have to be with me and but I can't watch them all the time when I'm doing chores so we just do our best, you know"* (interviewee #25). This material-deficit explanation was echoed among some farm safety providers, who while their work was grounded in the knowledge-deficit paradigm, they also acknowledged that high childcare costs and inadequate childcare services make it difficult for farm parents to adopt their farm safety recommendations as illustrated by this farm service provider: "*When we do presentations and when we work with farmers, and when we work with a lot of organizations that are service providers, our recommendation is always childcare, for you know whether that's an actual childcare center whether that's having a neighbor watch your child it's getting the child into care and out of that worksite so that's always the first option. But, as we know, with all the challenges in rural areas that isn't always feasible, so the second best thing is to have a safe play area*" (interviewee #29).

While we did not explicitly ask about the interaction between children and farm parents' wellbeing, the key informants consistently brought this issue up. More specifically, interviewees spoke about how the emotional and material aspects of raising children (as they pertain to farm business and farm safety) can have negative impacts on farm parents' mental health. From an emotional perspective, some interviewees spoke about the constant worries and/or guilt parents have in regard to the idea that their children could get hurt. A farm organization representative explained: *"Especially when we're looking at the seasons when we're planting or harvesting or there's a lot of things happening on the farm, I think. it's always in the back of your mind how are we keeping the kids safe, which provides an extra stressor when you do have the kids with you on the farm and how do you ensure that everyone who enters the farm knows that there are kids there and that they need to be aware of that."* (interviewee #27) while a farm business service provider reflected: "*I think the worst case scenario is your one of your children gets hurt on the farm or another child gets hurt on the farm and I, you know I have just seen that happen, and it is really, really a heavy lift for women to have to get over that because the guilt is overwhelming*" (interviewee #14). Others spoke about the consequences of the disconnect between the romanticized view of raising children on the farm and the difficult reality as illustrated by this farm organization representative: "*Where folks have an idea that they can do it all that they can make enough money to live and save the environment, and you know tend to their children and their family needs like just by doing this farming thing and the reality ends up being often that like either the mental piece doesn't work out or the tensions with actually having the time and the ability to provide for your family in terms of you know wellness and child care and things like that don't line up with the farming or what's best for the land or best for the environment, often doesn't make the economic return that drives the other systems*" (interviewee #1). From a material perspective, interviewees spoke about the stress of juggling personal and professional responsibilities and the lack of support parents have. A farm business service provider recollected: *"I actually had one extension employee who worked at a different county office that I supervised. She had a dairy and two kids that were kind of close in age, like my two boys were. She was really struggling with this work being at home and helping on the farm. I had lunch with her one day she was crying she didn't know what to do. Right so I'm getting her to those employee assistant resources that she needs I'm sharing my personal experience with her. She ended up taking a leave of absence from work to be at home because she was having issues with childcare*" (interviewee #11). This group of key informants shared how parents stress is compounded by the need to grow their farm business while constantly needing to adapt their farm business and care strategies based on the availability of childcare options; the age, number, and needs of children; and personal preferences. These challenges were largely seen as most acute for farm families with younger children, limited family support to look after the children, and lack of financial resources to pay for childcare.

Messiness and complexity of the factors shaping the integration of children and childcare aspects in farm programming

The analysis revealed several factors explaining whether interviewees and their organizations integrate children and childcare topics into their program, and the degree to which they incorporate these topics. These factors include: the demographic characteristics of farmers the programming serves, the needs of farmers, the program's conceptualization of the agri-family system, the program's scope of work, the organizational structure, the available resources, and the interviewee's lived experience. These factors are presented in a simplified tabular form (Table 3). As the integration of children and childcare topics in farm programming was rarely explained by just one factor, the goal of the tabular presentation is to provide a simplified way of presenting the factors and patterns identified, over developing an absolute typology.

Given space limitations, we describe one explanatory factor in detail to illustrate how the table should be read: how demographics of the program's target farm population influence the integration of children and childcare in program development and deployment. Interviewees explained that programs tend to target specific farmer needs (e.g., farm transition or farm safety) and demographics (e.g., women farmers or young farmers). On one hand, among those interviewees least inclined to cover children and childcare in their programming were those delivering service to older farmers (i.e., farm transition and retirement) or those that tend to attract men (e.g., production oriented topics). On the other hand, interviewees most likely to integrate childcare and children tended to serve young farmers and farmers whose children were younger (e.g., beginning farmer and farm children safety programs). It is particularly striking that despite women continuing to serve as primary caregivers, programs targeting women in agriculture did not actively, intentionally or explicitly create or provide programming related to children and childcare.

We consistently found the reasons why children and childcare are or are not included in farm programming are the product of multiple interacting factors. For example, one farm safety service provider had raised their children on a working farm and spoke honestly about the challenges of finding childcare for themselves and other farmers. However, their program did not address childcare other than recommending farm parents arrange for adult supervision off the worksite. Reflecting on the reasons why their coverage of childcare was limited, they spoke to a tension (which we heard among

TABLE 3 Factors explaining the level of integration of children and childcare aspects in programming.

Little/no integration	Explanatory factors	Integrated in programming
Older farmers (e.g., farm transition and retirement programming)—men (e.g., production oriented topics)	Farmers served by programming	Younger farmers (e.g., beginning farmer programs)—Young kids (e.g., farm children safety programs)
Not aware that childcare is a problem—Don't know about childcare as a problem—Push back from farm sector on safety regulations—No data to determine if a problem	Farmers' needs	Aware that childcare is a problem—Challenges with childcare have worsened because of COVID-19
Household and business = separate entities: Business needs to pay for itself and interviewee want to limit the entanglement of the professional and personal spheres	Conceptualization of agri-family system (i.e., interviewees' conceptualization of the relationship between the farm household and the farm business and the role each play)	Household issues = business issues: holistic approach to the farm whereas household-level issues have direct implications on the farm business
Children/childcare aspects not connected to scope's of work—Childcare challenges bigger problems than what organization can offer	Program/organization's scope of work	Grassroots nature of the organization and importance of addressing farmers' needs—Addressing childcare issues is connected to changing the narrative around how farmers are supported
Large and/or organization with top-down management limit ability to develop programming	Organizational structure	Small and/or organizations with flat hierarchy provide the space to react quickly and try innovative programs
No grants available to do this work—Decrease in capacity due to budget and staff shrinkages	Availability of resources (time and money)	Farmer member-funding gives emphasis on responding to their needs—Use of COVID-19 relief funding to expand programming on childcare
No children—Wife providing childcare	Lived realities and experiences of interviewees[a]	"I have been there": first-hand experience with raising children, with childcare challenges

[a] While our demographic questions were limited to farming background, age, and educational attainment, interviewees frequently volunteered information about their personal life providing key insights into their lived realities.

other interviewees) wherein they struggled to reconcile their recognition that farm safety recommendations were financially and materially challenging for farmers, but at the same time felt childcare is a bigger issues than what their organization can address. The following quote from this interviewee speaks to the heart of this tension and further illustrates the complex and competing forces influencing program development and deployment. "*You know that's one of those messages that I say don't and then I hate when I have to say don't because is there an alternative that I can also give them rather than just saying don't do this. Remember, I talked earlier about self efficacy if you feel you can make a change, you probably will [. . .]. If I say a parent don't just leave your kids you know don't bring them to your worksite well they will say I have to work and there's things to do so I guess, I have to just bring them. So there's certain things on the farm that it's hard as a safety professional to advocate for if I don't have a system or another alternative to offer them*" (interviewee #3).

Discussion

In what follows, we first provide a summary of our findings to answer these three questions and discuss connections with the existing body of knowledge. As a reminder our research questions were: (1) How do farm service providers and farm organizations integrate topics connected to children and childcare in their programming? (2) What are farm service providers and farm organizations' perspectives on the interactions between children, farm business, and farm safety? and (3) What factors shape the integration of children and

childcare topics in programming? Then, pointing to a key tension in our findings, we provide possible explanations around four interconnected themes. These are grounded in the women in agriculture literature on farm programming and farm organizations, the body of work that in part informed our study design.

Summary of findings

In direct response to our first research questions, we found that, despite children being ubiquitous to family farms and despite childcare being a key farm safety strategy, the coverage of children and childcare aspects in farm programming was overall limited and largely inconsequential with an overall lack of practical guidance and resources to support farm parents in balancing the children, their safety, and farm work. This finding is not surprising. We noted the dearth of research on childcare for the agricultural sector in our introduction. In addition, Gallagher (1) and Hartling et al. (25) noted the lack of research evaluating farm safety interventions targeted to the youngest children while Inwood et al. (77) has noted the lack of attention to health insurance, another household-level issue, in the farm business programming. Within the landscape of the farm programming we assessed, those focusing on the farm business were more prevalent compared to those focusing on farm safety, yet it was farm safety programs that were more likely to touch on children topics while both farm business and farm safety programs seldom covered childcare topics. With the exception of a handful of farm organizations in our two samples that were actively working to provide practical in support of farm parents, the frequent emphasis on knowledge-deficit and behavior change paradigms in programming echo previous findings on farm safety (1, 2, 25, 60) and farm business (78–80) programming. Speaking to the second research question, the limited coverage cannot simply be explained by a lack of awareness among interviewed key informants given the nuanced and layered set of perspectives on how children interact with the farm business, farm safety, as well as farm parents' wellbeing. Interviewees' descriptions of the short and long-term implications of children on the farm business, strategies to keep the children safe, and stress associated with juggling multiple role and worrying about the children getting hurt echo those provided by farm parents (13, 24, 27). The layered and nuanced understanding of the material and economic realities of raising children on farms is likely due to both first hand-experience of some interviewees and the frequent interactions with farm parents for others. In response to the third research question, a messy and complex range of factors explained whether and how children and childcare topics were integrated in farm programming. Given that actions are the results of interconnected multiple spheres of influence (42, 44, 45), some of the factors were within the purview of interviewed individuals (e.g., their conceptualization of the agri-family system), while others were connected to factors outside their control as they pertained to factors within their organization (e.g., organizational structure) or within factors fully outside their organization (e.g., availability of resources).

In sum, our findings point to a key tension. On one hand, there is a general understanding among those developing and deploying farm programming that raising children on farms can be challenging with direct implications on the focus of their programming (i.e., farm safety and farm business). On the other hand, farm service providers and farm organizations are rarely integrating these topics in their work or, when they are, it is largely inconsequential and most often focused on changing farm parents' knowledge and behaviors. Our findings interpreted through the lens of central themes from the women in agriculture literature point to four possible interconnected explanations.

Childcare work is not seen as farm work

Collectively and with variations among individual interviewees aside, our findings align with those of other researchers regarding how invisible practical, lived realities of raising children on farms can be. This includes lines of research on the invisibility of women's work (81, 82), farm women (31, 51, 83), and farm household-level issues (27, 84, 85). This also includes lines of research on the representation and integration of farm women in institutions pointing to women being underserved by educational programs (51, 55, 58, 59, 86), underrepresented in farm organizations (52, 53, 56, 87, 88), and their presence and contributions not included in farm statistics (54, 89, 90). The invisibility of women's work caring for children in comparison to the visibility of farm output work, traditionally seen as men's work, illustrate the undervaluation of women's work. This undervaluation of women's reproductive work over men's farm output production work has been discussed at length. See for example: (55, 57, 83, 91). We see evidence of this undervaluation in our data, even aside from the limited coverage of children and childcare topics. The initial reticence of some participants, citing not knowing about the topic, plus the self-reflections wherein some reported the interview helped them make new connections, speaks to the invisibility of childcare work on the farm.

Farm programming is about supporting the productive function of the family farm

In line with the traditional emphasis of farm service providers and farm organizations, the farm programming we

reviewed was largely about supporting the productive function of the family farm. The contours of what supporting the productive function entailed varied in part based on what is valued as farm work and what is not. Interviewees who perceived childcare as a problem, those who had first hand-experience raising children on farm and/or with childcare challenges, and those with a holistic conceptualization of the family farm (i.e., conceive that the personal and professional spheres overlap) were more likely to view the connection between children work and productive work. In turn, these interviewees were more likely to integrate children and childcare topics in their programming, be it formally or informally. While farm safety programs were primarily about the safety of children, their programming reflected the primacy of farm work over childcare work. Indeed, most of the farm safety programming was about keeping the children safe in the workplace while there was comparatively no practical programming to support childcare work. The limited coverage of children and childcare topics in programming targeted to women is on one hand surprising given that this programming is specifically designed to meet the needs of women. On the other hand, it could reflect farm women's desire for their professionalization and their identify as farmers in their own right (92) and support the finding that even women in agriculture programming has been found to not fully account for the complexity of their roles and needs (51, 58, 86).

The myopic focus on farm work topics, coupled with the limited coverage of childcare work in farm programming, connects back to the undervaluation of care work as noted above and illustrates which knowledge is seen as legitimate and which is not. The women in agriculture literature has previously noted both the oppressive and marginalizing nature of the farm programming and farm organizations for farm women, noting that which topics are covered and which are silenced reflect the preferred knowledge and prevailing power relations of a society (51, 55, 56, 58, 59, 87).

Alignment of farm programming with the traditional family farm model

Some of our findings indicate an alignment between programming with the agrarian ideal of farming as a family affair. Such alignment may limit the space for farm programming that would suggest a move away from the prevailing social and cultural norms of raising children on the farm. Evidence of alignment with this agrarian ideal include pictures of smiling families with young children in the worksite and statement around the benefits of raising children on farms in the farm programming material and through the embodiment and reinforcement of the expectations that children are looked after by family members largely on the farm by key informants. These findings connect back to the women in agriculture literature which has highlighted the ways in which farm programming and farm organizations tend to adhere to family farm ideals which contributes to reinforcing traditional divisions of labor (51, 53, 56, 58, 59, 87). Potentially in play for farm safety service providers is a fear of push back from the agricultural sector given pushbacks in the past against a proposed major reform of child labor and safety in the early 2010s (93, 94). Indeed, farm safety material included frequent mentions of the benefits of raising children on farms in tandem with lack of practical programming on childcare.

Mismatch between farm programming scope, resources available, and childcare challenges

A common pattern among interviewees was their discussion of factors connected to their larger environment as limiting the programming they can develop and deploy including mandated scope of work and access to resources. In particular, we found a constant push and pull between interviewees' perceived challenges, whether they believe they can respond to these challenges, and the context in which they work. As some interviewees noted, their programming is educational in nature, while the challenges of supporting a household on a farm income and/or using childcare are challenges that are structural in nature. This finding aligns with Calo (79) who found that prevalent knowledge-deficit approaches of young and beginning farmers on farm knowledge and skills fall short of addressing the structural nature of farm start-up challenges such as access to land and capital. The women in agriculture literature provides insights as to why those in leadership positions might not prioritize nor allocate funding for programs that would support farm parents, and working parents more broadly. Farm women, which as we noted above continue to be the primary caregivers, have historically been sidelined from leadership positions in farm organizations and political spheres. Given the important role of farm organizations in shaping the narrative for agricultural programming and policies, this means that decisions around which challenges should be addressed and how, along with how resources should be allocated have largely been made with little to no input from women and with little understanding of women's needs and realities (52–54, 56, 87, 88, 95).

Limitations

Our findings and their implications need to be understood in light of three main limitations. First, in our choice of search terms, we selected search terms that would allow us to identify the broader landscape of farm programs and resources in which

farm parents are embedded. We did not use "children" and "childcare" as search terms in the initial search phase. While this choice is a study limitation, we note that the findings from the key informant interviews align with those of the document review, indicating an appropriate coverage of our search terms. Second, our choice of qualitative methods coupled with a focus on three states was intended to develop an in-depth understanding of a topic that has received limited attention and to identify patterns. Our focus in this article was on the most prevalent patterns we identified in the data and as such do not fully speak to all of the information and perspectives shared by all informants. We recognize the need for further data analysis that explores in greater depth the margins of the patterns presented in this article. Furthermore, research assessing the same questions in other states is important to work toward the generalizability of findings. Our findings still likely provide important insights as we suspect that similar patterns to those we found will emerge. As noted in the methods section, our document review included national-level organizations. We also identified farm programming documents from national level clearing houses during our environmental scan. Though documents from states outside our study states were not included in our analysis, our informal review of these documents also suggested little to no coverage of children and childcare topics. Hinting to the potential to find similar patterns in other states, much of farm programming topics and funding priorities continue to come from the U.S. Department of Agriculture while state branches of large farm organizations tend to follow the programming and advocacy priorities set by the national-level organization. Last, childcare challenges as well as the undervaluation of care work are not unique to our three study states. Third, our positionality as female researchers, our prior work on this subject, or our affiliations may have biased responses provided by interviewees. We worked to minimize the bias though our interview introduction, non-leading questions and probes. Furthermore, during the coding and analysis phase, we had several conversations about the biases we might bring and ways to limit them.

Conclusion

Farm safety experts have indicated that a reason for the continued high fatality rates among by-standing non-working farm children is in part explained by the low uptake by farm parents of recommended safety practices including the key strategy of adult supervision off the worksite (6–8). Yet the reasons why farm parents are using or not using childcare have received scant attention in the literature. The social systems in which farm parents make safety decisions for their children influence choices including childcare use. Thus, our analysis of 92 farm programming documents and 36 interviews with farm service providers and farm organization in three U.S. states assess how these actors address the intersection of children and childcare with farm work and farm safety. Overall, we identified a key tension in our findings whereas despite a layered and complex understanding of the challenges farm parents face juggling work and the children among most interviewees, few programs explicitly integrated children and childcare topics. Interviewees pointed to a complex and messy mix of individual and structural-level factors as shaping whether or not they integrated these topics in their work. Our interpretations, grounded in the women in agriculture literature, of this key tension led us to identify four possible and overlapping explanations around the valuation of care vs. farm work; the traditional emphasis of farm programming on the farm business; alignment of the programming with the agrarian ideal of the family farm; and the mismatch between farm programming scope, resources available, and childcare challenges.

Our findings in tandem with the theoretical and empirical insights from the women in agriculture literature raise concerns about the invisibility of children and childcare topics for farm programming, with all that such invisibility implies. Farm programs and farm organizations that do not adequately account for women's realities nor value their contributions deter women from participating and can reinforce societal norms around gender and divisions of care and farm work (51, 54, 87, 96). Social and cultural expectations around children growing up on farms and participating in farm work have been identified as a barrier to farm safety (13, 14, 16, 20). Yet the embodiment and reinforcement of these norms in farm programming could be counterproductive to achieving the goal of limiting children's exposure to risk because it implicitly indicate limited acceptance and space for farm parents who either cannot or do not want to adhere to these norms. Practical implications coming out of these concerns include hiring and retaining staff with a diversity of identities and lived experiences at all level of the organizations to re-think their programming while addressing organizational gender biases so that farm programs can reach a wider range of farmers on a wider range of topics (51, 55, 59, 96–98). The women in agriculture literature also points to the need to move away from top-down models of farm service provision and to instead move toward participatory programming models whereas farmers are seen as experts in their own right. One way to do that is by creating space for farmers to learn from one another (51, 58, 59). The practical realities of raising children on farms and implications for farm business and safety along with the provision of information on resources to ease childcare use need to be integrated in existing farm safety and farm business programming. To avoid reinforcing gender stereotypes and to make visible the realities of juggling children and farm work, it is crucial that the integration should not be limited to programs targeting women (52, 53, 56, 59, 87).

The mismatch between farm programming scope, resources available, and childcare challenges is harder to resolve given

the structural factors at play around childcare access and cost. In turn, these findings reinforce the importance of multi-dimensional approaches as farm service providers alone cannot be expected to address complex problems (79). In the short-term and in-line with the farm organizations that most integrated children and childcare in their programming, farm service providers and farm organizations can augment their programming through collaborations with other groups working on childcare. This means collaborations with family and consumer education service providers (e.g., from extension services and state agencies of family services) and childcare advocacy groups to help connect farm families to childcare resources such as referral services and financial support. At the same time, farm service providers and farm organizations can serve these family and consumer service providers by recognizing that raising children on farms can be stressful and making sure that their programming accounts for the lived-realities of farm families such as non-traditional work hours, seasonality of the workload, cost, quality, and availability of childcare, and self-employed status (as it pertains to financial support eligibility criteria). In addition, farm organizations have a role to play by advocating with policy makers and departments of agriculture at the state and federal level for the broadening of farm programming so that it is inclusive of issues impacting the farm household over solely the farm business. In this advocacy work, farm organizations should collaborate with childcare advocacy groups as these groups already have experience and expertise addressing childcare challenges. At the same time, given that childcare advocacy groups tend to focus on urban areas, there are opportunities to build on the recent work from the U.S. Department of Agriculture and U.S. Department of Health & Human Services (99) on rural childcare initiatives by ensuring that the needs and realities of farm families are incorporated in this work.

Two lines of research to investigate emerge out of our study. The first line of research needs to tease out the adequacy of the four themes we identified to explain the key tension in our findings. Given that these themes were grounded in the women in agriculture literature, one approach to future research could be through a formal gender analysis of farm programming in the U.S. but also beyond the U.S. This could include an assessment of how farm service providers and farm organizations understand care work to overlap with or depart from farm work. The second line of research needs to assess the implications of the invisibility of children and childcare in farm programming. Most relevant to the farm safety field, this includes the need to understand the extent to which the reinforcement of the social and cultural norms of raising children on farms is limiting the use of childcare. Farm service providers might call on these social and cultural expectations to relate with the farm families. Yet and connected to the findings of Janssen and Nonnenmann (100) and Neufeld and Cinnamon (101), our findings raise questions about the lessening of trust in farm programming among farm parents when the programming does not account for their lived realities and stress of raising children on the farm. Our findings also raise questions around the consequences of reinforcing social and cultural norms around raising children on the farm and of not making space for alternative approaches on the use of childcare by farm parents.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Marshfield Clinic Research Institute and The Ohio State University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

FB: funding acquisition, project administration, conceptualization, data collection, data curation, data analysis, and writing—original draft and editing. SI: funding acquisition, conceptualization, data collection, and writing—review and editing. AR: conceptualization, data collection, data analysis, and writing—review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Some differences but all at risk: Improving farm safety for young people—An Australian experience

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A significant portion of on-farm deaths and injuries in Australia occur among young people working on the farm. Since most Australian farms are still family owned and operated, young people are an integral part of everyday operations and the farm is a place where these young people live, work and play. This paper describes how the international Gear Up for Ag Health and Safety™ program, originally developed in North America, was further developed for a younger Australian audience (ages 12–19) enrolled in agricultural programs at secondary or vocational schools. In addition, we share insight on demographics, self-reported farm safety behaviours, and the most common farm tasks being performed by program participants utilising a pre-survey originally developed for program customisation. Of particular importance were the most common farming tasks reported by this group. The most common tasks performed on Australian farms included a large variety of vehicle use (farm vehicles, motorbikes, and quadbikes) and handling livestock. Females reported operating vehicles and other farm equipment at the same rates as males. Males were more likely to be working with large heavy machinery and driving trucks, while females were more likely to be working with livestock and using horses for stockwork. Both males and females reported low use of PPE and poor safety habits. In future Australian programs, it will be important to address the conspicuous use of motor vehicles, quadbikes, motor bikes and machinery at early ages, and to target gender-specific tasks to reduce risks on the farm.

KEYWORDS

risk, schools, farm, gender, peers, safety, agriculture, young adults

Introduction

In Australia, agriculture, forestry and fishing has the highest rate of workplace fatality per 100,000 workers across all industries (1). The majority of these injuries are caused by vehicle crashes (quadbikes, motorbikes, tractors, utilities, trucks) and being hit by moving objects, including vehicles and machinery. According to a recent study by Peachey, from 2001 to 2019, 15% of all farm-related fatalities were youth under 15 years. Of these deaths, a third were visitors or bystanders at the farm and more than half had no active supervision by an adult (2). The major causes of both youth and adult deaths and injuries on farms are similar—quadbikes, tractors, farm vehicles, motorcycles; plus horses, contact with animals and water bodies for young people under 15 years (2, 3). Other occupational risks such as noise induced hearing loss and respiratory disease are also known to be higher in farming populations (4, 5) and linked with farm work exposures. Despite the known high-risk nature of agricultural vehicles, quadbikes and farming work, farmers and farming families continue to take risks on their farms.

The majority of Australian farms are family-owned and operated with farming families commonly described as families where at least one adult is a farmer or farm manager (6). Due to the family nature of farm operations, farms combine a functioning workplace and family home—that is they are where people live, work, and play. Due to this overlap of work life and home life, children and young adults are often exposed to a range of occupational hazards, and consequently learn much of their safety behaviours and attitudes from observing their parents, farm workers and siblings. Cigularov et al. (7) noted that young people (age 13–18 years) who are engaged in farm work and perceive a positive safety environment are more likely to communicate mistakes to their parents when the parents showed concern for safety. Peers (friends and school colleagues) can also be an important point of influence for shaping safety culture, although as noted by McBain-Rigg and colleagues this influence can have a positive or negative effect (8, 9). The role of the family and peers is important as previous research has shown a broad distrust of safety information coming from people with little or no farming experience making it difficult for safety professionals to provide meaningful input (10, 11).

Globally, most agricultural safety training programs and interventions are designed and targeted at younger people, aged 5–12 years (12, 13), and include a variety of formats such as the Progressive Agriculture Safety Day, Farm Safety 4 Just Kids or programs that are developed and delivered specifically in place such as the Hesse Farm Safety program (13, 14). However, whilst most programs show increases in knowledge, long term evaluations are limited and mostly remain unpublished (15, 16). The enduring Canadian primary school program "Safety Smarts"—running since 1998—showed that students increased their awareness and knowledge of farm hazards and built pro-safety attitudes that endured as they matured (17). A key success factor noted by the external evaluators was the first hand farm experience of all the facilitators which enabled trust building (17). Despite some success with primary school age programs, few studies globally have examined the impact of agricultural health and safety programs with young people aged 12–19 years old. As a result, there remains minimal evidence around what works. This is also reflected in Australia where there is a current gap in the provision and evaluation of engaging safety content for young adults (12–19 years) living and working in agriculture (2, 18).

A farm's safety culture is influenced by various factors including the culture of people on farms to act in a safe manner. However, these decisions, choices and attitudes around safety are shaped by family, schools, industry, community mores, and the policy of state and federal government legislative frameworks (8). For example in Victoria, Australia, under the Occupational Health and Safety Act 2004 (19), you need a permit to employ children under 15 years and must comply with the minimum age, hours of work and rest break requirements. Yet, for children working or helping on a farm (or other family business) these obligations do not apply as family businesses are exempt (20). This situation is common in many state and international jurisdictions, where family farms are treated differently to other businesses.

In understanding the broader elements that impact farm safety, Bronfenbrenner's socio-ecological model (SEM) (21) defined the five layers (self, interpersonal, community, organisational, and policy) which can each have an effect on a person's development. This interaction between self, family/community and school environment, and the broader political or government landscape shapes personal growth. Changes or conflict in any one layer can affect another (22). The SEM has been used previously to consider the broader issues in agricultural health and safety (8, 23, 24), with Lee et al. adding a sixth layer—child—as the first level (see Figure 1).

The international Gear Up for Ag Health and Safety™ program (Gear Up for Ag™) was designed to address a number of the key layers of the SEM framework (21). Developed by the Ag Health and Safety Alliance (AHSA), a non-profit organisation based in the US, Gear Up for Ag™ was developed to train 18–25 year olds in a range of agricultural health and safety topics (12).

This program was originally launched in the U.S. and Canada, and has trained more than 5,000 young adults in agriculture, globally. Preliminary findings have found that the program leads to shifts in knowledge on safety behaviours, especially those related to safe quadbike use, eye safety, hearing conservation, and sun protection. The training impacts participants, since most of them report being more aware of agricultural safety and health issues following the program and are very likely to engage in discussions about safety topics with their family members, coworkers, and peers.

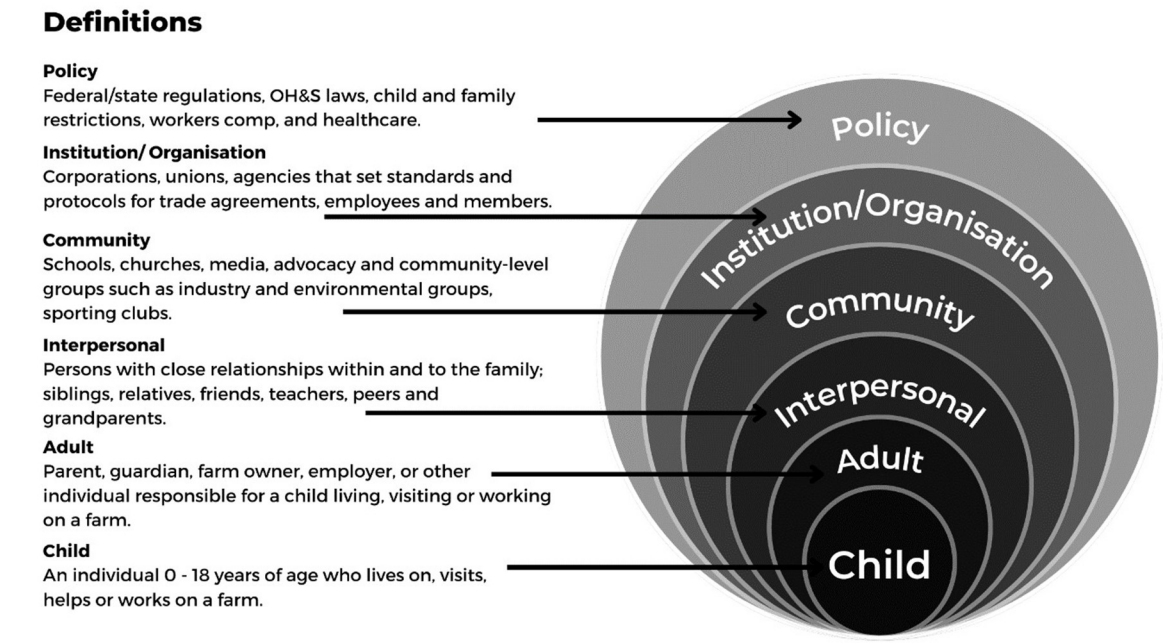

FIGURE 1
The socioecological model adjusted for young people and farm safety. Adapted from Lee et al. (23).

Up to one third of U.S. participants also state that they purchase additional safety equipment, such as PPE, following the program (12).

In 2018, experts from AHSA provided a train-the-trainer experience to assist in localisation and adoption of the Gear Up for Ag™ program pertinent to the Australian environment. The international visit and collaboration focussed on increasing local expertise for an interactive intervention to provide young people with evidence-based safety information about a range of agricultural health and safety topics. Following piloted programs in 2019, the Australian Gear Up for Ag™ program was further adapted to focus on a slightly younger audience, aged 12–19 years in secondary schools that were involved in agricultural studies or attended schools in farming communities.

Materials and methods

The Gear Up for Ag™ education program is facilitated by Agricultural Health and Medicine graduates (25, 26) and/or industry representatives. All facilitators were required to have completed the train the trainer program and have a background in health (usually registered nurses), education and/or experience in farming or agricultural extension. A minimum of two facilitators were required to attend any Gear Up for Ag™ education program and ensure a combination of both health and agricultural expertise.

Figure 2 illustrates the five-stage process that is completed for each Gear Up for Ag™ education program. Student participants were from 13 secondary or vocational training organisations across the state of Victoria, Australia. The students may or may not have been enrolled in agricultural studies, but all attended school or vocational training [competency-based education (27)] in farming communities where they visit, work casually or help friends and family on farms. Gear Up for Ag™ was a useful introduction to the competency-based Certificate II/III courses. Several of the schools had their own small working farms with a variety of enterprises including horticulture to livestock where safety procedures were being taught and reinforced. Although the general purpose of the Gear Up for Ag™ program is to conduct educational and training outreach, the objective of this paper is to apply program evaluation techniques to share demographics, self-reported farm safety behaviours and analyse common farm tasks being performed including analysis by gender using SPSS 28 (28). It is hoped that this will help inform future delivery models and areas for wider analysis.

Pre-program engagement

A key part of the program is engagement with the respective teachers. With cooperation and support of the school, a pre-survey of students attending the program is completed 2–3 weeks prior to commencement. This pre-survey ascertains the types of farming undertaken, age, and common activities and tasks students engage in on farm. Understanding of the

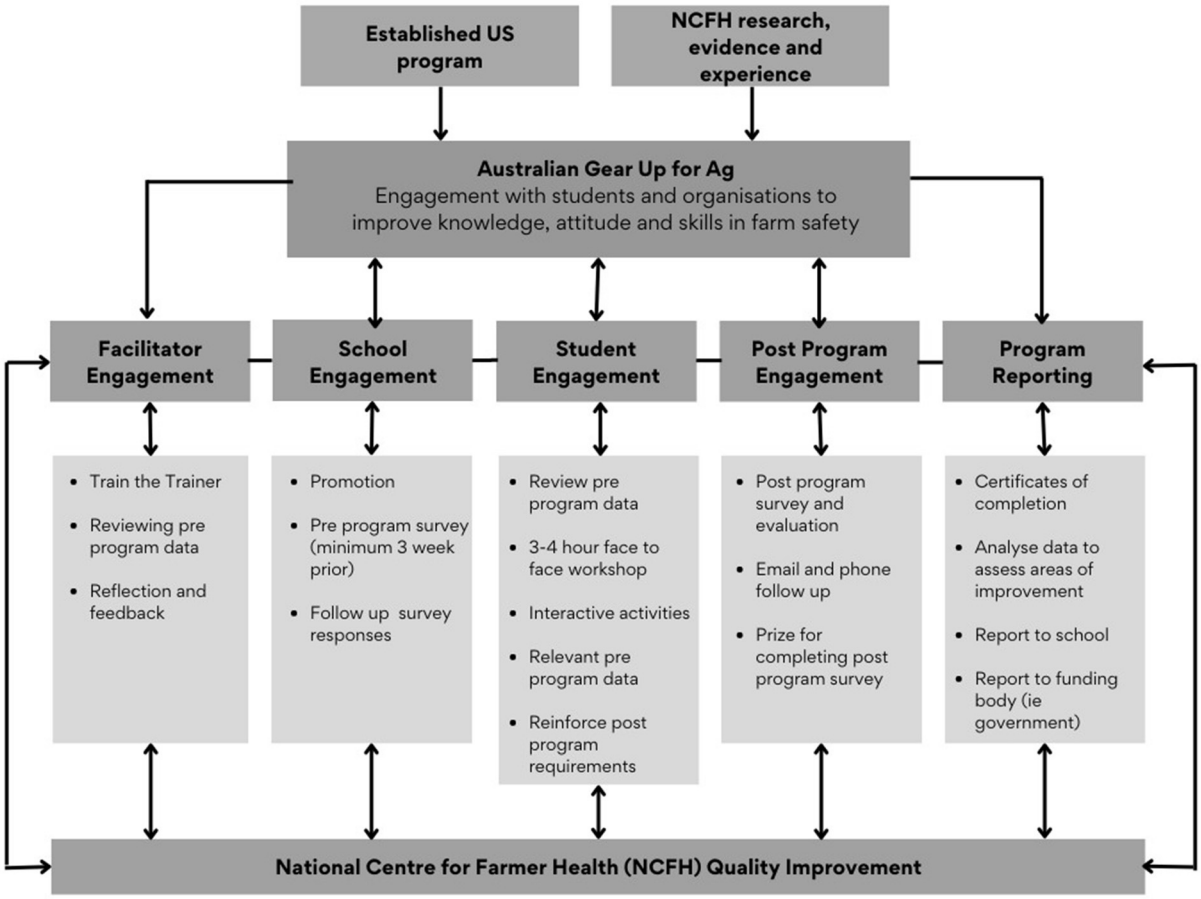

FIGURE 2
Method and process for delivering a Gear Up for Ag™ education program.

common agricultural tasks and types of farming undertaken is very important to allow for refining of the content and tailoring to the audience. This contextualisation is crucial to the integrity and method of the program as farming industries/commodities are heterogeneous—the experience of a young person growing up and/or working on a dairy farm is very different to that on a cropping farm. A recent report into general safety interventions has urged education programs to consider the influence of context on interventions, noting that interventions are often "borrowed" from other organisations and not adjusted to meet specific needs (29). The pre-survey also identified current and contextual safety behaviours along with ascertaining if students were concerned for the safety of others such as families, or friends. In Australia, farmers are often presumed and promoted in social media to be male. As outlined by Brumby, it was important that all involved with the program were cognisant of not reinforcing or propagating stereotypes of male hegemony (30). To assist in shaping the material and understanding the role of gender and common farm tasks undertaken proportions were also calculated for common farm tasks undertaken in the last 12 months. A Two Sample *Z*-Test for Proportions was used to determine if tasks undertaken by males and females are different from one another and assess the relationship between farm tasks and gender.

Face-to-face education program

A 3–4 hr education program is undertaken and includes general and specific information on agricultural hazards (as outlined in the pre-survey data), such as noise, machinery, livestock, large plant, motorbikes, quadbikes, tractors, horses, workshop equipment, dust, and agrichemicals. A mixture of giving information, undertaking discussion, reflection and interactive activities/ quizzes are utilised and practical advice on ways to work safely to minimise risk of injury and illness on farms. For example, an interactive activity using shaving cream to illustrate how agrichemical contamination on clothing and

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TABLE 1 Demographics and safety habits of participating students pre-program ($N = 301$).

Characteristics	Male *n* (%)	Female *n* (%)	Total *N* (%)
Total study participants	162 (54)	149 (46)	301
Age (in years)	16.39 (3.80)	17.07 (5.60)	16.7 (4.84)
Mean (SD)			
Age groups	66 (41)	60 (43)	126 (42)
13–15 years			
16–19 years	84 (52)	66 (48)	150 (50)
≥20 years	12 (7)	13 (9)	25 (8)
What are you currently studying?			301
Agricultural science- secondary school	49 (30)	47 (34)	96 (32)
Certificate II or III in agriculture	65 (40)	58 (42)	124 (41)
Certificate II/III in animal studies	4 (2)	5 (4)	9 (4)
Other	44 (27)	29 (20)	72 (23)
Do you currently work and/or help on a farm?			301
Yes	125 (77)	91 (66)	216 (72)
No	37 (23)	48 (34)	85 (28)
What age did you start working on the farm?			301
4 years or younger	51 (31)	24 (17)	75 (25)
5–8 years	28 (17)	26 (18)	54 (18)
9–12 years	32 (20)	24 (17)	56 (19)
13–14 years	15 (9)	16 (12)	31 (10)
15 years or older	18 (11)	22 (16)	40 (13)
N/A I have never worked on a farm or in agriculture	18 (11)	27 (19)	45 (15)
Do you worry about the safety of family/friends on the farm?			301
Yes	111 (68.5)	106 (76)	217 (72)
No	44 (28)	26 (19)	70 (23)
I don't know anyone who works on a farm	7 (4)	7 (5)	14 (5)
How important do you think your own health and safety practises are on the farm?			301
Extremely important	81 (50)	76 (58)	157 (52)
Very important	49 (30)	40 (29)	89 (29)
Moderately important	24 (15)	18 (13)	42 (14)
Slightly important	3 (2)	2 (1)	5 (2)
Not at all important	5 (3)	3 (2)	8 (3)
Do you ride a quadbike on the farm?			301
Yes	113 (70)	84 (60)	197 (65)
No	49 (30)	55 (40)	104 (35)
Do you ever have passengers when riding on the quadbike?			197
Yes	70 (62)	48 (57)	118 (60)
No	43 (38)	36 (43)	79 (40)
Do you wear a helmet when riding a quadbike on the farm?			197
All the time	34 (30)	26 (31)	60 (30)
Most of the time	24 (21)	17 (20)	41 (21)
Occasionally	21 (19)	17 (20)	38 (19)
No I do not wear a helmet	34 (30)	24 (29)	58 (30)
Do you wear respiratory protection when working in dusty environments?			301
All the time	19 (13)	6 (4)	25 (8)
Most of the time	28 (27)	22 (16)	50 (17)

(Continued)

TABLE 1 (Continued)

Characteristics	Male *n* (%)	Female *n* (%)	Total *N* (%)
Occasionally	49 (30)	24 (17)	73 (24)
I do not wear respiratory protection	48 (30)	42 (30)	90 (30)
N/A I never work in dusty environments	18 (11)	45 (32)	63 (21)
Have you ever had short of breath, cough, fever or chills after being in a dusty environment?			238
Yes	36 (25)	31 (33)	67 (28)
No	107 (75)	63 (67)	171 (72)
In the past year have you been exposed to any loud noise on the farm?			301
Yes	128 (79)	91 (65)	219 (73)
No	34 (91)	48 (35)	82 (37)
In the past year have you mixed, handled or applied, agrichemicals on paddocks, livestock, in the dairy or around the home?			301
Yes	73 (45)	56 (40)	129 (43)
No	89 (55)	83 (60)	172 (57)
Of those currently working or helping on farm ($n = 216$)—Do you supervise others on the farm?	125 (57)	91 (43)	216
Yes	55 (34)	46 (33)	101 (47)
No	70 (43)	45 (32)	115 (53)
Who do you supervise? (may supervise either or both)			101
Siblings	45 (36)	37 (40)	82 (81)
Other workers	20 (16)	17 (19)	37 (37)

PPE can easily be transferred, ingested, and absorbed. Students often shared storeys of their experiences of farm accidents or injuries, identifying causes such as speed, no helmet, or seatbelt, and used language such as "unlucky," and "done it before without a problem" (31).

Post-program engagement

A post-survey is administered 4–6 weeks following the program. This time frame allows students to apply new knowledge, have safety discussions, and make possible changes in safety practises and behaviours to reduce risk. A particular focus is if the student had subsequent health and safety discussions with family, friends, or peers aligning with the influential factors described in the SEM framework of influences (21, 23). An incentive of going into a draw to win a half face respirator was offered to encourage survey completion.

A short 10 question survey is also sent to the responsible class teacher for completion post the Gear Up for Ag^{TM} Program. This consists of six questions using a five point Likert (32) score based on communication, balance between activities and information and discussion, maintaining students interest, and applicability to the students work and life. Four open ended questions asked about any ongoing classroom discussion post-program and for recommendations for improvement.

The Deakin University Human Research Ethics Committee executive reviewed the Gear Up for Ag^{TM} Health and Safety Evaluation (2021-256:) and found it to be compliant with the *Ethical Considerations in Quality Assurance and Evaluation Activities* guidelines (33) and no further ethics review was required.

Results

From February 2021 to June 2022, there were 301 participant responses for the pre-survey. These were from students who attended the Gear Up for Ag^{TM} education program. Demographics are presented in Table 1, along with whether they work on a farm, and supervise others.

Most students were in their teens. Half the students were aged 16–19 years and 42% were 13–15 years old. The most common study being undertaken was the Certificate in Agricultural Studies (41%), followed by Agricultural Science as a secondary school subject (32%). Other courses included Victorian Certificate of Applied Learning (VCAL), and Certificate in Engineering with an agricultural focus.

Forty-five students (15%) had never worked on a farm with a third intending or wanting to. For those who had previously undertaken work or lived on a farm ($n = 256$), over half commenced at 8 years old or younger. Of those currently riding

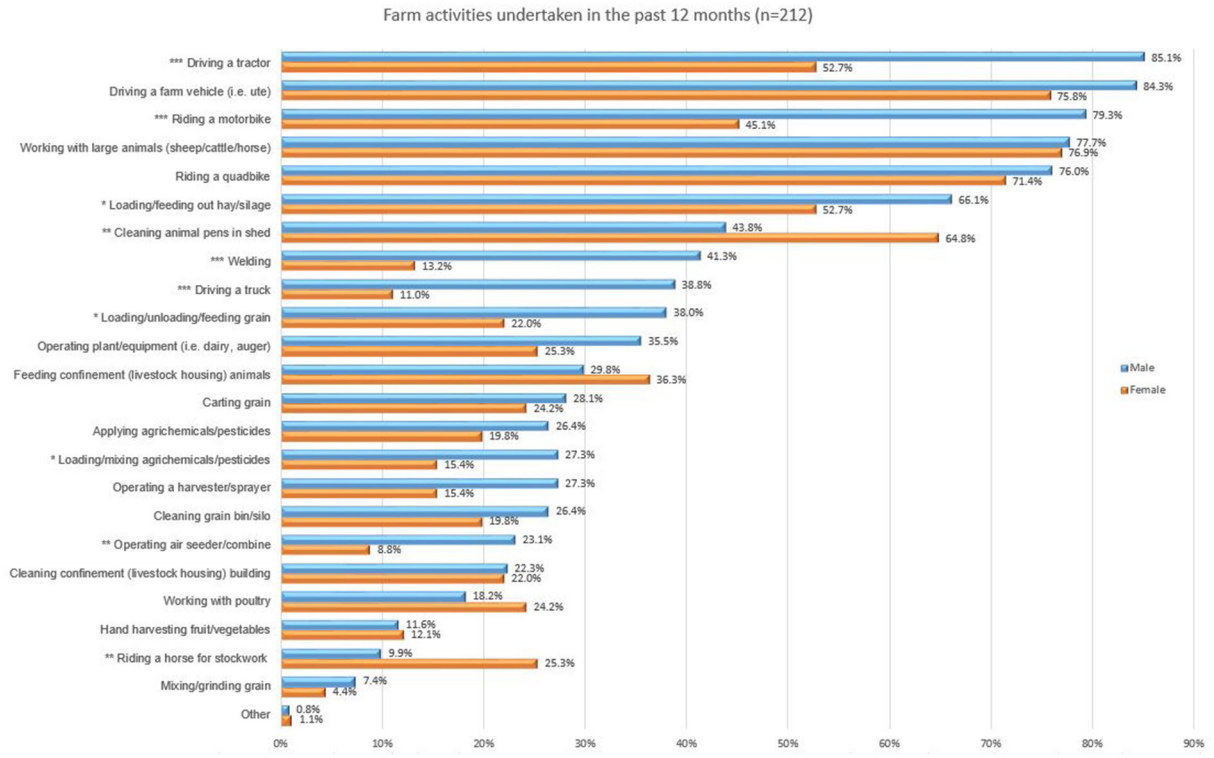

FIGURE 3
Proportion of participants reporting common tasks undertaken in last 12 months. *Significant difference between males and females using a Two Sample *Z*-Test for Proportions where ***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.05$.

a quadbike on farm ($n = 197$), only half wear a helmet most or all the time and 60 per cent carry passengers. Reported quadbike behaviours were similar for both males and females. Seventy-two percent reported having been exposed to loud noise on the farm and 42 per cent had mixed, handled, or applied agrichemicals. Twenty-eight percent reported having experienced shortness of breath, fever, cough or chills after being in a dusty environment. Less than half wore respiratory protection most or all of the time in dusty environments. The majority (72%) indicated they worried about the safety of family or friends on the farm, and during the workshop some students articulated the implications of an injury or illness and subsequent effects of families (31). Over 80 per cent believed their own health and safety practises on the farm were important or extremely important. Of those currently helping or working on the farm ($n = 216$), 47% currently supervise others, with the majority being siblings and this was similar for males (36%) and females (40%).

As shown in Figure 3, the most common farming tasks undertaken in the last 12 months included those most likely to injure or result in fatality, such as riding a quadbike, driving a tractor or other farm vehicle and working with large animals. Quadbikes in Australia have often accounted for the highest number of farm fatalities, having at times surpassed tractors (1). This is despite the guidelines from manufacturers and industry organisations that people under the age of 16 years should not ride quadbikes or take passengers (34).

A Two Sample *Z*-Test for Proportions (28) was used to determine if tasks undertaken by males and females are different from one another. The two-sample *Z*-test is a common method used to evaluate proportional differences between two groups of interest. Where there was a statistically significant difference this is shown with an asterisk on Figure 3.

Ten of thirteen schools responded to the stakeholder survey which was sent to the responsible subject teacher. Seven schools rated communication as excellent, six strongly agreed that the Gear Up for Ag^{TM} program provided information and knowledge that added to their curriculum, and 100% agreed or somewhat agreed that the information was relevant to the students' lives, work or studies. All schools either strongly agreed or agreed that the program involved a good balance of information, hands-on activities, and discussion. Nine of ten schools who responded (90%) indicated that since the program, they had discussed some of the farm safety topics further with the students. Topics such as quadbike safety, biosecurity/zoonotic disease prevention, and agrichemical safety were the most likely to be discussed. All

agreed they would recommend the Gear Up for Ag™ program to other schools.

There were 158 responses for the post-survey. A post-survey rate of 52% is a pleasing result, given the history of low response rates in other agricultural studies. Typically most survey response rates for academic studies of US farmers are ∼20% (12, 35) and a recent study in Scandinavia found slightly higher results depending on whether email or post (36). On the post-survey, all students were given the opportunity to provide feedback in the form of a written, qualitative response. A third of the students reported that they or their families' had taken action to improve farm safety. Examples that were given included the fitting of roll over protection devices onto quadbikes, and the purchasing of additional personal protective equipment (PPE) such as safety goggles, respiratory masks, bike helmets, ear muffs, steel capped boots, chemical gloves and overalls.

Discussion

Information on the tasks being performed by the students is important—not only to help inform and tailor future programs to the audience, but also to inform outreach messaging and future communication or safety campaigns. One of the major findings from this program is that vehicle use is a big component of farm work for the students and there is a heavy reliance on young people to undertake these tasks. Farm sizes in Australia are large with an average of 4,331 hectares, although farms in the state of Victoria are smaller (37). Due to the size and scale of farms the need for vehicle use (utilities, quadbikes, motorbikes) for transportation on the farm is required. This does make the farm environment in Australia different from other industrialised farming countries such as the US, UK, Canada and Europe where farm sizes are smaller (38).

Clearly the work undertaken on farm by young people is a core and key activity to the farm business. As shown in Figure 3, the most common tasks reported included those most likely to injure or kill on farm, such as driving farm vehicles, riding motorbikes and quadbikes (1, 2). This is despite the guidelines from manufacturers indicating that people under the age of 16 years should not ride quadbikes. The wearing of helmets was particularly low in those riding quadbikes, with only half wearing helmets most or all the time. Interestingly a higher rate of helmet wearing was noted for those riding motorbikes with 78% wearing helmets most or all the time. Additionally, the carrying of passengers on quadbikes is not recommended at any time for adults, let alone for young people under 16 years who should not be using the quadbike anyway (34).

Traditionally farm work, media and safety campaigns have seen a strong male bias, simply because most farmers were assumed to be males, distorting the reality of farming for both men and women (39, 40). As the results demonstrate, this is not the case, with females riding quadbikes, driving farm utilities, operating plant and equipment and working with large animals at the same rates as males. However, there were differences noted between genders as shown in Figure 3. Whilst males were significantly more likely to be working with large heavy machinery and driving trucks, females were significantly more likely to be working with livestock (including handling large animals) and using horses for stockwork. These task-based results were similar to those reported among young adults enrolled in the U.S. Gear Up for Ag™ program (12). Horses are the major cause of injury and death from animals in Australia (2, 3), and one area where there is significant differences between the genders. A recent paper by Shisler and Sbicca (41), highlights the variety of predominantly feminine-coded work on farms—such as feeding, stockwork and working with animals and explores the space of carework and farming and an expanded role beyond the masculine ideal. Females are doing significantly more "cleaning of pens" than males, and highlight the opportunity for future education programs to focus on proper PPE for cleaning campaigns and feature females performing the work, including driving vehicles, stockwork on horses, operating plant and equipment and cleaning pens.

The reported rates of hearing protection use (always or mostly) in noisy situations (32%) and use of respiratory protection (always or mostly) in dusty conditions (25%) by the students was low. As a comparison, 81% of young adults enrolled in the U.S. programs reported wearing hearing protection always or mostly (12). This difference between nations is concerning, especially since noise induced hearing loss is high in farming populations in Australia and the low rate of hearing protection use is concerning as once damage is done, it is not repairable (42–44). These findings highlight a significant lack of safety behaviours and the need to undertake further work with students to protect against occupational risks.

Finally, this work has highlighted that 47% of secondary school students supervise their siblings in the most hazardous workplace in Australia. This major finding highlights an opportunity to consider the key role of siblings, family and the broader community and industry in which agriculture and farming sit. As shown, there remains room for improvement in both awareness and practise of basic farm safety habits and those who are supervising younger siblings can assist in improving the culture for all. Importantly 52 students had discussed safety with their family post-program and also taken action to improve safety.

Future steps to address the findings of this program highlight the role of using schools to educate young people on farm safety as a valuable yet an underutilised component to the broader influence of safety culture. As highlighted by the elements from the SEM (21), it is also important that education provided external to the farm environment such as

schools, peer based educators, and community based materials is consistent with safety messaging received on-farm from the primary farm worker and industry (45). For example the recent Victorian Farmers Federation's (VFF) "Making Our Farms Safer" campaign provides safety education and resources for farm owners, parents and peer groups (46). There is also a need for policy and strategic partnerships to support the expansion and availability of programs and educational content targeting children of primary school age (under 11 years) in order to see safety messaging "reinforced" rather than "introduced" once youth reach their teen years. Additionally, the impact of any educational programs and resources requires consistent and sustained evaluation to determine the effect youth education programs are having on the indicators of farm safety culture.

Limitations

There is always the potential of bias when relying on self-reported surveys. One way that we addressed the bias is that the pre-survey occurred in a time frame that was before the Gear Up for Ag^{TM} program was delivered onsite, so there was less potential to influence student responses. In addition, the post-survey and stakeholder survey was administered 4–6 weeks post-program, allowing people time to think about it. One limitation to the survey method is that although the same participant group completed the pre- and post-surveys, these responses are not paired. Numbers in the study were smaller (for example, 301 responses to the pre-survey) and prohibited more complex analysis of demographic factors and survey responses. However, the Gear Up for Ag^{TM} program is focused around improving educational programs through outreach and were not originally designed to conduct research and instead are primarily used for program customisation is not necessarily a research program.

Conclusion

The Gear Up for Ag^{TM} program has highlighted not only areas of risk for individual students but the broader safety risks to siblings, peers, parents, schools and the farming community. Addressing the very common use of vehicles, machinery and equipment at an early age and the targeting of gender specific tasks to reduce risk must be considered in the development and delivery of any future programs and policy shifts. The Gear Up for Ag^{TM} program has also illustrated the intrinsic value of discussion and the importance of subsequent student to family conversation to prompt safety action. Giving young people the language and tools to think about safety and articulate concerns is empowering for any young person whether off or on the farm.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Deakin University Human Research Ethics Committee. Written informed consent for participation was not provided by the participants' legal guardians/next of kin because: Deakin University Human Research Ethics Committee executive reviewed the Gear Up for Ag^{TM} Health and Safety Evaluation (2021-256:) and found it to be compliant with the Ethical Considerations in Quality Assurance and Evaluation Activities guidelines.

Author contributions

SB, CS, and DS contributed to the original piloting of Gear Up for Ag in Australia. TH and CF conducted the data collection. MS and SC the delivery of programs. TH and SB undertook the data analysis. SB, JC, and JG the drafting of the manuscript. JC, TH, and CF provided guidance and supervision throughout the study. All authors contributed to the study design, reviewing and editing of the manuscript, and approved the final manuscript.

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Conflict of interest

Authors JG, DS, and CS were employed by Ag Health and Safety Alliance.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Legal responses to child endangerment on farms: Research methods

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In the US agriculture (including ranching) is among the most dangerous industries and it is the only one where children of any age are permitted in the worksite. Whether working or not, children are at risk of serious injury or death when present among the many hazards associated with agricultural work. In most cases the proximate cause of a traumatic incident involving a child (<18 years) is an adult's choice to allow the child's presence in a high-risk situation. Yet, little is known about the legal repercussions for a responsible adult when such events occur. With an overarching goal to enhance the culture of safety for children in agricultural settings, this project includes three phases: (1) identification and collection of public records and news reports regarding legal action following a childhood agricultural injury or fatality; (2) analysis of the proposed or imposed legal responses following these agricultural injuries and fatalities; and (3) development of recommendations for public agencies responding to events that lead to a criminal complaint or the imposition of non-criminal child welfare or other civil measures. This paper describes the project's mixed methods study design that yielded extensive details on 12 legal cases as well as perspectives from key informants on the strengths and limitations of legal responses to child endangerment on farms. Integration and analyses of data from quantitative and qualitative sources will be used to generate recommendations, including guidelines and protocols, for key stakeholder groups.

KEYWORDS

child, endangerment, farm, agriculture, legal action, death, injury

Introduction

In the US, it is estimated that a child (<18 years) dies about every 3 days in a farm-related incident and that about 33 children are seriously injured every day on farms (1). Agriculture has been and continues to be one of the most dangerous occupational sectors according to the Bureau of Labor Statistics (2). The nationwide federal law does not set any federal age limitations for children who are working on family farms under the direction of parents or guardians (2). It is not only workers who are injured. In fact, about 60% of agricultural-related injuries are sustained by non-working children who are merely bystanders (1). A wide body of childhood agricultural injury literature is available from the US and many other countries. Updated statistics and several international commentaries are included in this special *Frontiers* issue.

Despite the frequency of childhood agricultural injuries and fatalities, responsible adults are rarely held accountable when a child is neglected or allowed in a dangerous setting. In launching this study, the team contacted numerous law schools, legal clinics and professional organizations to inquire on this topic, yet, virtually all respondents indicated they were not aware of legal cases involving child endangerment on farms, only of civil charges typically associated with equipment failure. To our knowledge, this is the first study of its kind. The goal of this project is to map legal cases where a parent/adult was prosecuted for child endangerment or neglect related to the death or serious injury of a child younger than 18 years. Specific aims include collecting data on actual legal cases; gathering perspectives of key informants and subject matter experts; interpreting findings from cases and informants; then generating recommendations for action. The reality is that family farm children are at an increased risk because they are on their home grounds, where they live and play contiguous with the worksite (3). Appropriate work assignments and keeping children separated from dangerous agricultural operations are required to mitigate risks. This project's end-goal is to influence the culture of safety in agricultural settings by raising awareness of adult accountability for safeguarding children from known dangers on a farm.

The term "accident" continues to be used by the general public but safety professionals prefer the term "incidents" as more reflective of the reality that all such events are preventable. The *2012 Blueprint for Protecting Children in Agriculture*—a national action plan, called for research that guided safety and health interventions for children in agriculture (4). While there have been many studies and interventions related to childhood safety on farms, there are no known publications or reports that assessed the legal consequences following serious farm-related injuries (which we defined as long lasting or permanent; the most common found was the loss of a full or partial limb) and fatalities on farms.

In broad outline, this project, which is a matter of first impression, collects, maps and analyzes legal cases where a parent/adult was subjected to legal consequences related to these childhood deaths or serious injuries in an agricultural setting, during the selected time period of 2015–2021. To gain further insights, interviews were conducted with key informants to solicit experiential perspectives on when and how legal consequences are determined and carried out. Conclusions and proposed recommendations will be reviewed with various stakeholders and advisors to gain their perspectives, raise awareness, and prompt action when indicated.

Knowing the sensitive nature of this study, the project team established several guiding principles to ensure fidelity to the overarching goal of better safeguarding children:

- a belief that all children deserve equal protection from harms, whether on a commercial or family farm or in agricultural or non-agricultural settings;
- the project's intended "audience" is public officials who are charged with responding to these fatalities or serious injuries; and
- exploring the greater use of civil penalties as alternatives to criminal prosecutions, such as community service, farm safety audits and parenting classes, have the potential to induce positive changes.

The study methods, protocols and data collection instruments were reviewed by the Institutional Review Board (IRB) of Marshfield Clinic Health Systems. The IRB approved the study as exempt because personal health information was not collected. This paper highlights the project's explanatory sequential mixed methods research design.

Study design

An explanatory sequential study design consists of first collecting and analyzing quantitative data then determining what type of qualitative data will help explain initial findings. Qualitative data is then collected and analyzed. The final step is integrating both data sets to interpret findings (5). As noted in Figure 1. This method provides a more holistic view of a situation, allowing both objective and subjective findings to form the basis of conclusions (6).

Quantitative data included demographic as well as legal data from publicly available sources. Child agricultural injury/fatality events were defined as non-fatal and fatal injuries that occurred on an agricultural work-site or involving agricultural machinery to those younger than 18 years. The "responsible parent/adult" was defined as the individual who was charged by law with being the onsite "supervisor" of the child victim. Those included parents, non-parental guardians or work supervisors at the time of the incident. Criteria for inclusion was a serious agriculture-related injury or fatality that resulted in some form of either proposed or imposed legal action against a responsible adult.

Qualitative data was gleaned from in-person meetings, telephone interviews, scheduled video meetings and e-communications with stakeholders, and advisors. The collected information was entered into a data collection tool (i.e., REDCap), which was used to fill pre-determined dataset fields to be analyzed by the project team. Integration of both data sets involved a series of telephone and in-person team meetings where discussions led to consensus on implications of individual cases and then generated conclusions based on the full dataset.

Data sources

There is no comprehensive national database for either proposed or imposed legal action associated with childhood agricultural injuries and fatalities. Searches for cases were primarily conducted using federal and state Departments

FIGURE 1
Mixed methods: Explanatory sequential design.

of Labor, federal and state Occupational Safety and Health Administrations, law offices, law schools, district attorney associations, child welfare agencies, offices of state Attorneys General, offices of local district attorneys, Lexis+, Westlaw, AgInjuryNews.org (7), Google Alerts, and internet searches.

Lexis+

Lexis+ is a subsection of LexisNexis, a legal research database for legal case law research. The project team used the advanced search option with keywords to search for cases. The keywords used were, "Prosecution, Child, Agriculture, Injury, Fatality, Child Labor, Negligence, Legal Action, and Child Protective Services." When potential cases were identified, the tabs citing decisions or other citing sources allowed the project team to assess if the incident met inclusion criteria.

Westlaw edge

Westlaw edge is a database for case law research from Westlaw. The project team used the advanced search option with keywords to search for cases. The same keywords were used as in Lexis+ and then applied to searches among secondary sources including trial court orders, statutes and court rules, regulations, briefs, and proposed and enacted legislation.

If sufficient data could not be identified from Lexis+ or Westlaw Edge additional internet searches, news media article searches, and court record database searches were conducted to assess if the incident met study inclusion criteria. Of the sources used, cases that met the selection criteria were only found using AgInjuryNews.org, Google Alerts and internet searches.

AgInjuryNews.org

The AgInjuryNews.org website is a publicly accessible free database of agricultural injuries and fatalities. Using the date, country/region, and age filters on the website the reports were filtered to display only relevant cases. The project team visited the source uniform resource locator (url) for the filtered cases to determine whether the case met study criteria. Google searches were conducted for the identified cases to look for additional data on each case.

Google alerts

Google Alerts is a publicly accessible free service offered by Alphabet Inc. to monitor the internet for new content. The project team created a google alert using keywords such as- "Prosecution, Child, Agriculture, Injury, Fatality, Child Labor, Negligence, Legal Action, and Child Protective Services." The alert was set to provide results once a day and a filter was applied to limit the results to the US. When a childhood agricultural injury or fatality event was identified by the alert, the project team reviewed the source article and conducted Google searches to seek additional data.

Internet searches

The project team conducted internet searches using browsers such as "Google," "Internet Explorer," "Microsoft Edge," and "Yahoo" to locate data on childhood agricultural injury and fatality events. Once cases were identified, internet searches were used to find publicly available court records and additional news articles for our data collection process. Additionally, first person perspectives on criminal charges and their consequences were secured from department of labor representatives, district attorneys, Mothers Against Drunk Driving (8) representatives, and news reporters.

Data

Selection criteria

Due to the retrospective nature of the study, this project did not recruit participants. All data collected on the subjects (the responsible parent/adult) were available through public sources. If the data identification source met selection criteria (only US cases from 2015–2021 involving youth younger than 18 years on farms and ranches), an in-depth search was conducted using news articles and court records to obtain data. The minimum dataset consisted of date, location of incident, injury agent, age

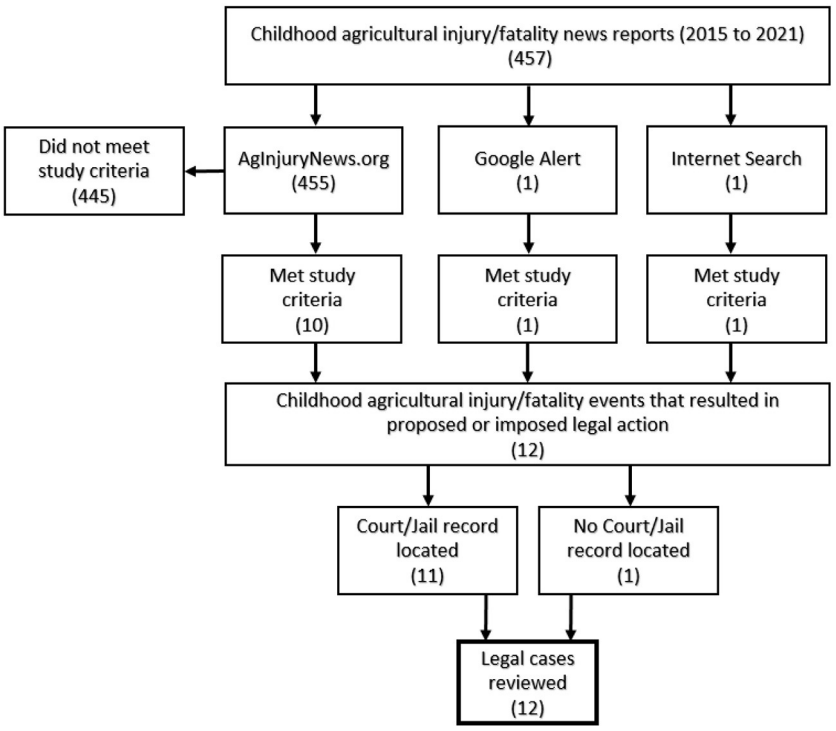

FIGURE 2
Legal case identification.

of victim, name of person responsible and their relationship to the victim, and the proposed or imposed legal action. A case would be excluded if, for example, a public record or news article mentioned an ongoing investigation but no subsequent information was located regarding an ensuing criminal or civil complaint. See Figure 2. Cases meeting all criteria were entered into the custom-designed REDCap data collection tool. Cases with incomplete data or from international sources were filed separately for potential, later reference.

Court records

Court records in the US are generally publicly available (9). However, sealed court documents, closed hearings and sensitive personal information are more the rule when involving children or medical information. This hampered many search outreaches.

Publicly available court records were located using state-specific online portals. The project team searched for publicly available court records corresponding to the identified cases by identifying the online portal for the state where the incident occurred. Most portals required information such as "first name," "last name," "county," and a date range for when the case was filed. Using these data points the publicly available court records for the identified cases were located.

REDCap data collection tool

REDCap is a secure software used to create and manage surveys and databases (10). A REDCap data collection tool was created by the project team and consisted of 57 fields. Each identified child agricultural injury/fatality event was assigned a project specific case number. The case number was a four-digit numeric field. The first two digits corresponded to the sequence in which the event was found and the last two digits corresponded to the year that the event occurred. For example- the first event found in 2015 would be labeled "0115," the next event would be labeled "0215." Other fields were narrative text fields, portable document format (pdf) uploads, date field, button lists (select one of the following), and checkbox lists (selecting from multiple options). The data collection tool consisted of 35 text fields, 12 file upload fields, seven button lists, two checkbox lists, and one date field. The use of the REDCap data collection tool ensured that the data abstraction process for the identified cases was conducted in a consistent fashion, free from bias. On average, the project team spent about 1 h analyzing all court documents and news reports for each case to understand the legal terminology and ensure consistency in REDCap data abstraction. A final quality review included a 2-day in-person meeting where the REDCap data set for each case was reviewed, allowing for a final check for errors.

Common as well as unique findings across the cases were documented separately and then used to generate questions for key informants.

Qualitative data collection

For qualitative data the collection process included methods to secure information, resources, and perspectives from individuals in positions to provide insights on specific cases and/or related issues such as actions taken by child welfare agencies, working in collaboration with legal entities. Methods included presentations, in-person meetings, telephone interviews, video meetings, and e-communication. The project team took notes from each event then subsequently discussed their relevance for achieving study objectives.

Phone contacts

The project's legal consultant created a cover sheet for phone calls to potential data sources and trained the research coordinator on how to conduct phone interviews with lawyers and public officials. The research coordinator compiled lists of law offices that focused on agricultural injuries, non-profit organizations that focused on child safety such as Mothers Against Drunk Driving (MADD), and law schools with courses or clinics that specialized in agricultural law. The research coordinator and the legal consultant contacted these potential informants to request information on these types of injury/fatality events. In addition, individuals with experience in the field were invited to join a panel of experts subsequent to data collection to contribute to proposed recommendations for action.

E-communications

The project team compiled a list of the Directors of the states' child welfare agencies (also known as Child Protective Services) and a list of the District Attorneys Associations or equivalent. Regarding child welfare agencies, an initial email was sent to 62 individuals who held leadership roles in all 50 States and two US territories. After 2 weeks, only three responses (1.5%) were received, thus, a reminder email with "read receipt" was sent. The read receipts indicated that of the 59 reminder emails 21 (36%) individuals had read the email but did not provide a response. Four (7%) of DA associations responded to the email, of whom three provided relevant information for the project. Two agencies agreed to video meetings for further discussion.

Regarding District Attorney Associations, email addresses were secured for 44 states' district attorney associations or equivalent. An initial request for information was sent to 42 state-specific district attorney associations (or their equivalent) in the US; then after 2 weeks a reminder email was sent with a read receipt to the unresponsive associations. Only 19 (45%) associations read the email and, of these, four responded with a reply. This e-communication method yielded no data on additional cases, but some did offer valuable resources applicable to the project's recommendations. Electronic mail was also used to follow up with journalists and district attorneys for the cases that were already identified to either secure missing information or to look for additional cases.

Key informant interviews

There was no standardized questionnaire or interview tool relevant to this study, thus, the team pilot tested a series of questions. After each use, the set of questions was condensed and refined. The interviews aimed to seek a better understanding of the legal actions that were being taken on these incidents as well as the roles of various agencies. Additionally, the interviews yielded perspectives regarding the rarity of occurrences that met project criteria—in contrast to other types of child harm, endangerment or neglect.

A total of 12 Zoom online video meetings (11) were conducted with district attorneys, law professors, department of labor representatives, child welfare personnel, and child death review experts. Interview questions were emailed to interviewees at least 1 week prior to the meeting. Table 1 provides the primary interview questions. Each session began with a brief project overview with slides, as a means to share the study's purpose and guiding principles as well as to minimize bias in responses.

Analysis

Despite extensive searches and inquiries, only 12 legal (criminal) cases were identified that met study criteria from 2015 to 2021 in the U.S. After cases were documented into REDCap the project team thoroughly reviewed each case to identify variables of those charged and those not charged with a criminal offense or subjected to a civil disposition. Additionally, the project team identified which types of action (i.e., criminal, civil, or child welfare) were most commonly involved. During this process, the team entered notes requiring follow-up (e.g., pending court date) into the comments section of the REDCap tool. From these analyses, preliminary findings were collated across all cases and timelines were set to follow-up on pending actions.

News reports and court records provided information on roles of various stakeholder groups, including public enforcement agencies, incident scene investigators, private legal offices, child welfare agencies, advocacy groups and others. From this list, the potential participants for key informant interviews was generated. The scheduled video meetings provided a range of insights on legal actions taken (or not taken). Equally important, interviews with child welfare agency

TABLE 1 Interview questions submitted to key informants.

1.	Have you/your office had any experiences responding to a report that a child was killed or seriously injured on a farm? If so, can you briefly describe your experience?
2.	Have you/your office been involved in a legal response (action/decision) following a serious injury or death of child associated with an agricultural worksite or farm machinery? If yes, please explain (e.g., culpability, charges, penalties, contributing circumstances, etc.)
3.	With about 100 preventable child farm deaths each year, typically with an adult present, why do you think so few resulted in any criminal charges or civil complaints? How does this compare to non-farm cases of child deaths?
4.	The next project phase includes drafting recommendations for response by public agencies. Would you/your office be willing to review and comment on these?
5.	What else should we know about public agencies and their response to negligent adult practices that result in a child's death or serious injury in an agricultural setting?

personnel yielded valuable perspectives about approaches used in "hypothetical" cases, given that their data on child neglect and maltreatment is confidential.

This project's final phase will use findings and input from stakeholders and advisors to draft recommendations for action by first responders to injury events, district attorneys, child welfare staff, reporters and advocacy groups. Invitational roundtable discussions with stakeholders will consider next steps such as development of guidebooks to upgrade and amplify the protocols and practices of those public agencies when responding to these injury/fatality events, along with discipline-specific training *via* online sessions and in-person workshops. A final report that presents the study's overall findings and anticipated impact will be prepared and disseminated among relevant stakeholder groups, including, amongst others, the agricultural media and public and private law organizations.

Limitations

Several limitations were encountered and should be noted. During the data collection process, many news reports of incidents were located, indicating an investigation was pending; but there were no subsequent legal charges were filed. It was not possible to determine if further action was taken outside of the legal system such as child welfare services, or if the case investigation was simply closed. The cases that met the project criteria represent a very small subset of childhood agricultural injuries and fatalities. Another limitation was the lack of published literature on this topic, as well as the minimal guidance available from schools of law or legal practices. Thus, findings from this project cannot be compared to similar studies in the US or elsewhere.

Discussion and conclusion

This novel project addressed an issue that has the potential to influence the culture of safety affecting children living, working and visiting on farms and ranches. New methods were tested and adopted to gather data and gain perspectives on the legal response to child endangerment on farms. The difficulty in locating cases that met study criteria suggests that legal actions imposed on culpable adults are relatively rare in contrast to the significant number of preventable childhood agricultural injuries and deaths reported in news articles.

The project team does not seek to establish or inspire further punishment or community opprobrium of those responsible adults. Rather, much like the principles of restorative justice (https://restorativejustice.org/), penalties such as community service or training in farm safety aim to provide a measure of healing for the responsible party. Findings will be used to identify opportunities for improving the responses of the relevant governmental enforcement agencies following the injury or death of a child on a farm. The end goal is to raise awareness in agricultural communities about the civil and criminal consequences of child endangerment in work settings as a means to enhance the culture of safety for all children in agricultural settings.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://www.aginjurynews.org/.

Ethics statement

The studies involving human participants were reviewed and approved by Marshfield Clinic Research Institute Institutional Review Board (IRB). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

CB and BL prepared the initial draft and subsequent revisions of this manuscript. DB and MK contributed

equally to the review and refinement of the manuscript's description of methodology for conducting this study. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Agricultural youth injuries: An updated review of cases from U.S. news media reports, 2016–2021

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Introduction: Fatal and non-fatal youth (ages 0–17) injuries in U.S. agriculture continue to be a significant public health concern. Despite sustained work and attention from federally supported research programming, we continue to observe an unacceptably high number of life-altering and life-ending traumatic injuries to youth in agricultural environments. Likewise, there is still a gap in stringent systematic agricultural injury and/or illness surveillance at the federal level. This paper will provide an updated review of child agricultural injuries from U.S. news media reports, expanding upon this author team's initial 2018 report.

Methods: Data collection from 2016 to 2021 occurred as part of the AgInjuryNews initiative, and data were coded according to the Farm and Agricultural Injury Classification (FAIC) system and the Occupational Injury and Illness Classification System (OIICS). The AgInjuryNews system primarily contains news media reports. Categorical variables were analyzed and compared using a chi-square test. In addition, the Jonckheere-Terpstra test for trend was used to test the yearly change in the number of youth injuries.

Results: We observed a general decrease in agricultural injuries compared to the original 2015–2017 dataset. Younger children (<5 years-old) and males were more often injured and more fatally injured than older children and females, respectively. Males and older victims were more likely to suffer an occupational-related injury compared to females and younger victims, respectively. Vehicles remained a major source of injuries, with tractors comprising 28%, and ATVs/UTVs comprising 26% of all injuries. Roadway incidents involving tractors and UTVs were less often fatal compared to non-roadway incidents, while ATVs were more fatal on roadways.

Discussion: This updated review shows childhood agricultural injuries and fatalities continue to be a major public health concern within the US. It is unclear if the trend downward in injuries is due to reporting, data capture methods, or a true decrease in injuries. These data continue to be of interest to stakeholders in academia, public health, government, and private industry—user groups who regularly and consistently seek this type of

information, often from multiple data sources, including as registered users on AgInjuryNews.org. These data identify emerging issues within the industry and further inform national and international planning committees' work.

KEYWORDS

youth, child, agriculture, injuries, news reports, safety, media, AgInjuryNews

Introduction

Agriculture remains one of the most dangerous occupations in the US and is the only occupation where children are legally allowed and often expected to actively engage on the worksite (1, 2). As of 2014, an estimated 893,000 youth under 20 years of age live on farms, 454,000 of whom perform work on these farms, and an additional 266,000 are hired laborers under the age of 20 (1). Upwards of 25 million youth visit farms each year, 95% of whom are frequent or repeat visitors (3). Despite an abundance of materials and resources for safeguarding youth in and around agriculture, young workers are nearly eight times as likely to be fatally injured in agriculture compared to all other industries combined, with 48% of all youth occupational fatalities occurring in agriculture (4, 5).

Despite this, there is currently no central data repository for youth agricultural injuries or fatalities in the U.S. Even within the most respected information sources of occupational fatalities, the Bureau of Labor Statistics' (BLS) Census of Fatal Occupational Injuries and Illness (CFOI), gaps exist—particularly for working and non-working youth in agriculture (6). These gaps are well-described in the current literature, with a potential 88% of non-fatal agriculture-related injuries escaping traditional surveillance methods (7).

In a recent study of U.S. emergency department admissions, the authors uncovered 62,079 people treated for agricultural related injuries between 2015 and 2019, of which 30% of those injured were youth (age 0–17) (8). Approximately 10 children presented to U.S. emergency rooms with agricultural injuries every day during that study period (8). Furthermore, a child dies every 3 days in an agriculture-related incident, nearly half of which involve transportation (9).

The key aim of this paper is to provide an updated review of youth (age 0–17) agricultural injuries by analyzing data harvested from U.S. news media reports. Our previous review, published in 2018, was an initial exploratory look at the first national dataset of its kind (10). News media reports have shown to be a powerful and useful tool in supplementing existing data sets and providing surveillance to previously uncaptured injuries.

Given the ever-evolving field of production agriculture and limited availability of national agricultural injury surveillance data, an updated review is presumably welcomed, even necessary, for agricultural safety and health stakeholders in academia, government, and private industry—user groups who regularly and consistently seek this type of information, as evidenced by a recent report in safety (11).

Materials and methods

Data collection

Data were collected as part of AgInjuryNews operations; detailed collection methods are further described in separate papers (10, 12). Contributions to these data are regularly supplemented through formal partnerships with several of the U.S. NIOSH-funded Agricultural Safety and Health Research Centers, the Canadian Agricultural Safety Association, and informal partnerships with agricultural safety and health community leaders and stakeholders.

Coding of data

Data were coded according to the Farm and Agricultural Injury Classification (FAIC) system and the Occupational Injury and Illness Classification System (OIICS) (13, 14). The injury reports were collected, and coded by a primary data specialist. All cases were then coded (FAIC, OIICS, and AgInjuryNews codes) by a second coder, with agreement analyses suggesting "almost perfect" agreement ($\kappa = 0.85$, $\kappa_\alpha = 0.82$) (13). Finally, at least 10% of all injury reports were randomly selected to be reviewed and coded by a third coder for additional quality control. Coder reliability analysis showed a strong interrater reliability (13). Incident location is coded at the highest resolution available with a county-level minimum and geocoded using Google Maps Geocoding API (15).

Analyses

Descriptive and summary statistics were determined for all cases in AgInjuryNews from 2016 to 2021. Geographic distributions were mapped using Tableau. We compared demographics, incident year, and FAIC and OIICS codes across fatal and non-fatal injuries, occupational vs. non-occupational,

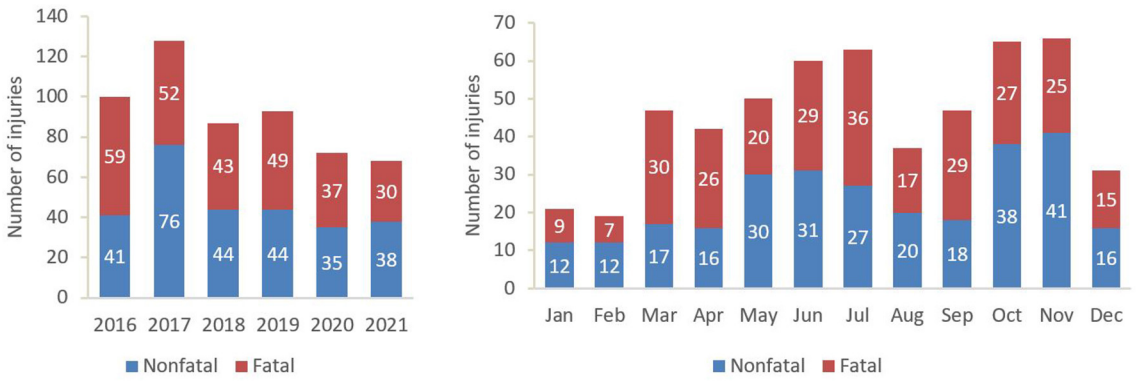

FIGURE 1
Yearly and monthly distribution of agricultural youth injuries.

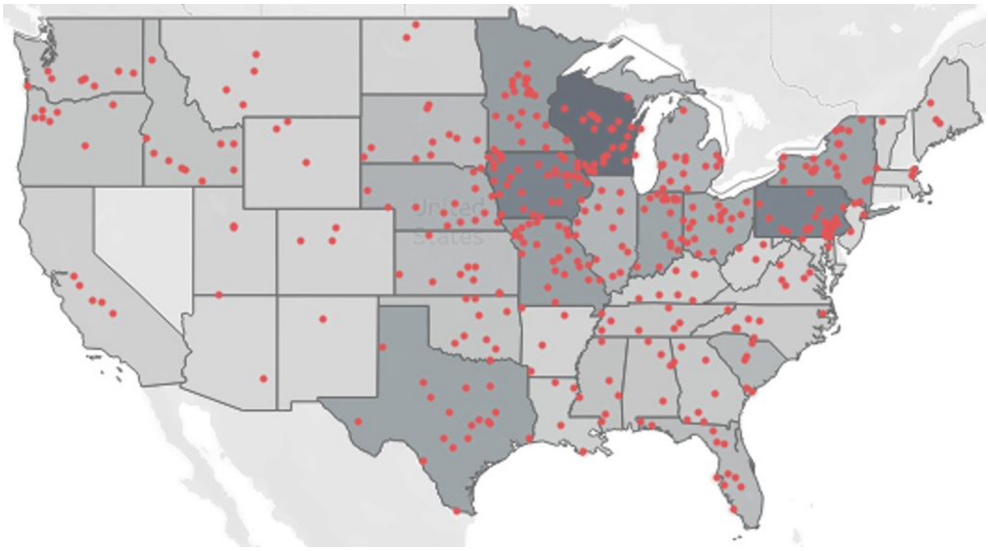

FIGURE 2
Location of agricultural youth injuries, 2016–2021.

tractor, and ATV/UTV injury cases, mirroring the initial review. Categorical variables were analyzed and compared using a chi-square test. In addition, the Jonckheere-Terpstra test for trend was used to test the yearly change in the number of youth injuries. Statistical analyses were conducted in IBM SPSS Statistics version 27.0.

Results

The study identified a total of 548 agricultural youth injuries (270 fatal and 278 non-fatal) between 2016 and 2021. Figure 1 summarizes the yearly and monthly distribution of youth injuries. The overall number of injuries decreased over time (p for trend 0.039 using Jonckheere-Terpstra) and peaked in 2017 with 128 cases. Most injuries occurred in November ($n = 66$) followed by October ($n = 65$) and July ($n = 63$; Figure 1).

Agricultural youth injury cases occurred in 43 states (Figure 2) and the top three highest numbers of injuries occurred in Wisconsin ($n = 53$), Iowa ($n = 43$), and Pennsylvania ($n = 42$).

Almost one-third of the victims were under 5 years old ($n = 132$, 28.8%). The <5 age group had proportionally higher fatal injuries than the other age groups ($\chi^2 = 8.258$, df = 3, $p = 0.041$). A total of 327 victims were male (73.6%), and the proportion of fatal injuries to male victims was significantly higher than fatal injuries to females ($P < 0.001$).

TABLE 1 Characteristics of injured victims, FAIC and OIICS codes, and injury severity between January 1, 2016 to December 31, 2021.

Characteristics	Total ($n = 548$)	Fatal ($n = 270$)	Non-fatal ($n = 278$)	χ^2
Age (valid $n = 459$)				
0–4 years	132 (28.8%)	88 (66.7%)	44 (33.3%)	$\chi^2 = 8.258$, df = 3, $p = 0.041$
5–9 years	120 (26.1%)	63 (52.5%)	57 (47.5%)	
10–14 years	116 (25.3%)	64 (55.2%)	52 (44.8%)	
15–17 years	91 (19.8%)	45 (49.5%)	46 (50.5%)	
Missing age* ($n = 89$, 10 fatal, 79 non-fatal)				
Gender (valid $n = 444$)				
Male	327 (73.6%)	202 (61.8%)	125 (38.2%)	$\chi^2 = 8.611$, df = 1, $p = 0.003$
Female	117 (26.4%)	54 (46.2%)	63 (53.8%)	
Missing gender* ($n = 104$, 14 fatal, 90 non-fatal)				
FAIC code (valid $n = 431$)				
Occupational	81 (18.9%)	44 (54.3%)	37 (45.7%)	$\chi^2 = 0.369$, df = 1, $p = 0.543$
Non-occupational	348 (81.1%)	176 (50.6%)	172 (49.4%)	
Undeterminable FAIC* ($n = 118$, 49 fatal, 69 non-fatal)				
OIICS-injury source (valid $n = 534$)				
Vehicles	392 (73.4%)	181 (46.1%)	211 (53.8%)	$\chi^2 = 15.922$, df = 4, $p = 0.003$
Machinery	63 (11.8%)	41 (65.1%)	22 (34.9%)	
Structures	32 (6.0%)	21 (65.6%)	11 (34.4%)	
Persons, plants, animals	27 (5.1%)	9 (33.3%)	18 (66.7%)	
Others	20 (3.7%)	13 (65.0%)	7 (35.0%)	
Unclassifiable Injury source* ($n = 14$, 5 fatal, 9 non-fatal)				
OIICS-injury event type (valid $n = 527$)				
Transportation	404 (76.8%)	194 (48.0%)	210 (52.0%)	$\chi^2 = 5.743$, df = 4, p = 0.219
Contact with objects and equipment	70 (13.3%)	34 (48.6%)	36 (51.4%)	
Exposure to harmful substances	25 (4.8%)	18 (72.0%)	7 (28.0%)	
Violence and injuries by persons or animals	12 (2.3%)	5 (41.7%)	7 (58.3%)	
Others	15 (2.9%)	7 (46.7%)	8 (53.3%)	
Unclassifiable injury event type* ($n = 22$, 10 fatal, 12 non-fatal)				

FAIC, Farm and Agricultural Injury Classification; OIICS, Occupational Injury and Illness Classification System.
*Missing and undeterminable/unclassifiable cases not included in the percentages or in chi-square analysis.
Column percentages are shown for "total." Row percentages are shown for fatal/non-fatal.

Occupational work-relatedness was determined by the FAIC codes. In 118 cases, FAIC coding was not possible because of a lack of information. Of those where work status was determinable, most injuries to youth were non-occupational (80.5%). There was no significant association between occupational relatedness and injury outcome (fatal or non-fatal; $p > 0.05$; Table 1). Agricultural injuries to youth mostly involved vehicles (73.6%) and transportation incidents (76.8%).

Characteristics of occupational and non-occupational injuries are given in Table 2. Most of the occupational-related fatalities and injuries were associated with the occupation of farming (FAIC-1, $n = 79$). Non-occupational injuries mostly occurred as a result of exposure to farm equipment, tools, and product hazards (FAIC-6, $n = 216$). A total of 95 youth occupants of other vehicles were injured in agricultural roadway incidents (FAIC-9). Other injuries were related to farm structures and landscapes (FAIC-7, $n = 31$) and non-occupational animal-related injuries (FAIC-8, $n = 6$). Males and the 15–17-year age group had higher proportions of occupational injuries.

Tractor-related incidents were associated with 153 injuries, and 77 of these happened on roadways (Table 3). Similar to the general results most of the victims in tractor-related incidents were males and in the 0–4 age group. In terms of the victims' roles, most of the victims were tractor passengers (39.6%). We identified 46 other vehicle victims injured as a result of tractor-related incidents on roadways. This included youth passengers ($n = 31$) and youth drivers ($n = 15$).

A total of 143 victims sustained injuries *via* ATV/UTV-related incidents, and more than half of these injuries were fatal ($n = 73$, 51%). Table 4 shows the injury characteristics of these

TABLE 2 Characteristics of occupational and non-occupational injuries.

Variables	Undeterminable*	Occupational	Non-occupational	χ^2
Year				
2016	18	17 (20.7%)	65 (79.3%)	$\chi^2 = 8.269$, df = 5, $p = 0.142$
2017	19	14 (12.8%)	95 (87.2%)	
2018	10	18 (23.4%)	59 (76.6%)	
2019	24	17 (24.6%)	52 (75.4%)	
2020	23	11 (22.4%)	38 (77.6%)	
2021	25	4 (9.3%)	39 (90.7%)	
Gender				
Male	23	70 (26.7%)	192 (73.3%)	$\chi^2 = 17.036$, df = 1, $p < 0.0001$
Female	65	6 (6.4%)	88 (93.6%)	
Age categories				
0–4	11	2 (1.7%)	119 (98.3%)	$\chi^2 = 67.050$, df = 3, $p < 0.0001$
5–9	22	12 (12.2%)	86 (87.8%)	
10–14	34	24 (29.3%)	58 (70.7%)	
15–17	23	32 (47.1%)	36 (52.9%)	

*Undeterminable variables not included in chi-square analysis.

incidents. Most of ATV/UTV injuries occurred as non-roadway incidents and more than half of the victims were youth operators (Table 4).

Discussion

This study of U.S. news media reports expands upon current known trends from 2015 to 2017, providing further insight into how the landscape of child agriculture injuries is changing. We continue to observe an overrepresentation of male injuries across all variables, notably seeing an increase in the proportion of males suffering occupational injuries vs. non-occupational injuries compared to females. Adult supervision is one known strategy for reducing injuries, however, some studies have found that supervision alone is not always effective in the agricultural environment, especially for young children, who lack the developmental abilities to remain safe in this environment (16, 17). Given the young age and non-occupational status of victims [81% of injuries occurred while youth were not working (Table 2)], a better strategy to prevent injuries and fatalities is the removal of young children from work areas and keeping young children away from farm vehicles and machinery.

Transportation continues to be the largest source of injuries to youth on and around farms. While tractors remain a significant injury agent, ATV/UTV injuries appear to trend downward over time. The cause for this is difficult to identify, as we have seen regulations surrounding these vehicles change on a county by county basis throughout several states (18, 19). This may also be due to a limitation in news agencies' tendencies to report on ATV/UTV injuries and incidents, as well as underreporting or reductions in seeking medical care. More in-depth analyses on the impact of ATV/UTV regulations and legislation on fatal and non-fatal injuries would help inform current and future policies.

As mentioned, tractors remain a consistent injury agent in these incidents, including youth operators, passengers, or bystanders. Over 50% of youth tractor injuries occurred to children under 10 years-old; however, age did not appear to have a significant impact on the fatality of an injury. Roadway incidents continued to be more fatal than non-roadway incidents, often involving non-farming victims in passenger vehicles. This emphasizes the need for tractor safety courses aimed at youth operators, as well as bystander and non-working youth safety in areas where tractors are operating. Some U.S. states require youth to be at least 16 years-of-age before operating a tractor; however, some states allow children as young as 12 to be certified for public roadway operations, and there are many exceptions for those remaining on privately-owned land, non-work related activities, and more (20, 21).

Overall, we observed a slight downward trend in injuries reported through news agencies and captured by the AgInjuryNews.org system. This is an excellent finding from this updated review, and suggests that injury prevention efforts with agricultural youth are having a positive impact. However, there may be other explanations for the downward trend. It is possible that some news media are shifting away from reporting on agricultural injuries, or instead focusing more on fewer, more serious cases. There is also the ongoing consolidation of farms across the U.S. and more corporate operations buy-out of smaller farms. These larger operations can be less willing to employ young workers, particularly young children under 14

TABLE 3 Characteristics of tractor-related injuries.

Variables	Tractor		
	Total ($n = 153$)	Fatal ($n = 61$)	Non-fatal ($n = 92$)
Year		$\chi^2 = 8.251$, df = 5, $p = 0.143$	
2016	29 (19.0%)	12	17
2017	35 (22.9%)	10	25
2018	23 (15.0%)	14	9
2019	20 (13.1%)	6	14
2020	27 (17.6%)	13	14
2021	19 (12.4%)	6	13
Age*		$\chi^2 = 5.717$, df = 3, $p = 0.126$	
0–4 years	42 (33.3%)	24	18
5–9 years	31 (24.6%)	10	21
10–14 years	21 (16.7%)	11	10
15–17 years	32 (25.4%)	12	20
Gender*		$\chi^2 = 0.071$, df = 1, $p = 0.789$	
Male	79 (73.8%)	39	40
Female	28 (26.2%)	13	15
Events*		$\chi^2 = 10.569$, df = 2, $p = 0.005$	
Roadway	77 (52.7%)	21	56
Non-roadway	60 (41.1%)	32	28
Contact	9 (6.2%)	5	4
Role*		$\chi^2 = 8.437$, df = 3, $p = 0.038$	
Tractor passenger	55 (39.6%)	20	35
Other vehicle occupants	46 (33.1%)	14	32
Bystanders	23 (16.5%)	15	8
Tractor operator	15 (10.8%)	5	10

*Undeterminable/unknown variables not shown and they are not included in chi-square analysis.

that may have otherwise performed work duties on a family-owned operation. The most recent, comprehensive data on the number of youth agricultural workers is from 2014, making this determination difficult.

This downward trend could also be due to changes in the manner of reporting that is not being captured by the current search methods of AgInjuryNews.org. While the system utilizes many avenues of data collection with comprehensive search terms, significant changes in the wording and content of news reports can result in a lower capture rate. Finally, it is unknown what effect the COVID-19 pandemic had on agricultural hazard and risk exposures involving youth. Some studies suggest that youth did spend more time in the workplace, particularly in 2020 (22). Still, our data herein, along with preliminary death certificate data analyses from the 2020 WI Farm Fatality report development, do not show an increase in the number of injuries or fatalities within that time frame (23).

Though our team reports a decrease of youth injuries in recent years, we cannot claim with any certainty that: (1) this represents actual counts of traumatic agricultural injury in the U.S. or (2) this decline will be sustained. While news media remain one of the few supplemental data sources for non-fatal agricultural injuries, continued monitoring of cases and, preferably, a more rigorous, centralized child agricultural injury surveillance program would be ideal. Expanding and simplifying injury reporting for small and non-employing operations can further improve capture rates of agricultural injuries.

Conclusion

We observed a slight downward trend in agricultural youth injuries reported through news media from 2016 to 2021, though we recommend continual monitoring of injuries therein. We also suggest further research and policymaker attention on public roadway safety (e.g., agricultural equipment lighting and marking), tractor operations and limiting

TABLE 4 Characteristics of ATV/UTV related injuries.

Variables	ATV ($n = 98$)			UTV ($n = 45$)			Total
	Total	Fatal* ($n = 55$)	Non-fatal ($n = 43$)	Total	Fatal ($n = 18$)	Non-fatal ($n = 27$)	
Year		$\chi^2 = 7.863$, df = 5, $p = 0.164$			$\chi^2 = 4.583$, df = 5, $p = 0.469$		
2016	22	17	5	4	1	3	26 (18.2%)
2017	26	10	16	16	4	12	42 (29.4%)
2018	15	8	7	5	2	3	20 (14.0%)
2019	10	6	4	6	3	3	16 (11.2%)
2020	11	7	4	10	5	5	21 (14.7%)
2021	14	7	7	4	3	1	18 (12.6%)
Age*		$\chi^2 = 1.684$, df = 3, $p = 0.640$			$\chi^2 = 1.287$, df = 3, $p = 0.732$		
0–4 years	9	4	5	4	1	3	13 (10.2%)
5–9 years	27	18	9	7	3	4	34 (26.6%)
10–14 years	40	22	18	17	9	8	57 (44.5%)
15–17 years	15	9	6	9	5	4	24 (18.8%)
Gender*		$\chi^2 = 1.074$, df = 1, $p = 0.300$			$\chi^2 = 3.922$, df = 1, $p = 0.048$		
Male	63	39	24	22	13	9	85 (65.9%)
Female	26	13	13	18	5	13	44 (34.1%)
Events*		$\chi^2 = 1.119$, df = 1, $p = 0.290$			$\chi^2 = 4.132$, df = 1, $p = 0.042$		
Non-roadway	84	45	39	37	16	21	121 (86.4%)
Roadway	13	9	4	6	-	6	19 (13.6%)
Role*		$\chi^2 = 8.950$, df = 1, $p = 0.003$			$\chi^2 = 2.730$, df = 1, $p = 0.098$		
Operator	51	34	17	14	7	7	65 (52.8%)
Passenger	33	11	22	25	6	19	58 (47.2%)

*Undeterminable/unknown variables not shown and they are not included in chi-square analysis.

extra riders, ATV/UTV usage and regulation, and an emphasis of removing young children from the worksite. Each of these priority areas should be of concern for youth injury prevention.

Media monitoring remains a powerful tool for agricultural injury surveillance, particularly fatalities, and youth cases. Digital reports, such as news media, obituaries, and social media posts, are valuable data sources in an industry lacking a comprehensive injury surveillance system. The AgInjuryNews.org system continues to provide a hypothesis-generating information and a strong foundation for collaborations and partnerships throughout agricultural health and safety, including international expansion.

The variety and vastness of our nation's farms and ranches pose serious challenges, with limited formal safety regulations, incentives, or enforcement. However, that should not dissuade us from doing what we can—taking steps toward creating a safer, more sustainable industry and workforce. Continued improvement of our surveillance and injury monitoring methods are essential to ensure accurate and actionable agricultural injury data, to better inform health and safety guidelines, resources, and public policy.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

All authors participated in the conception or design of the work, the acquisition, analysis, or interpretation of data for the work, drafting the work and revising it critically for important intellectual content, final approval of the version to be submitted/published, and all agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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International commentary: Child injuries on the farm: A brief commentary from Canada

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Introduction

It has long been established that children on farms are especially vulnerable to major injury. This is true in much of the world (1, 2), including our own country of Canada (3, 4). It is also true of children who grow up as members of farm families who reside on farm and ranch (i.e., large farm) properties (5), as well as children who frequent farms as occasional workers (6) or as visitors to the farm and its related worksites (7). In Canada, there is potential for children to be exposed to a diversity of mechanical, structural, chemical and other physical hazards associated with agricultural production activities (8, 9). Such hazards present risks for major trauma, injury, and disability (1–9). Patterns of injury evolve as children grow, develop and begin to take on essential work roles as part of the farm operation.

In this commentary we reflect on the current state of knowledge about the injury problem on Canadian farms. Our hope is to briefly summarize the current state of epidemiological evidence surrounding the child farm injury problem in Canada using evidence from our ongoing, national surveillance program (9). Building on this foundation, we will present evidence and opinion derived from international research about what works to prevent farm injuries among different groups of children. We will highlight the existence of policies and programs that are available within the Canadian agricultural sector and summarize barriers to the implementation of known effective strategies from the perspectives of health and safety professionals (e.g., Agricultural Safety Program Coordinators, Health and Safety Advisors, Farm Safety Consultants and Educators). who work with the farming community on an ongoing basis.

Fatal farm injuries to children: What we know

While agriculture is evolving in Canada with more corporate farms emerging in recent years, most farms continue to operate as family farms ("sole propriertorships" and "partnerships") with a heavy emphasis on the raising of grain and large animal

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TABLE 1 Fatal farm injuries to children 0 to 14 years in Canada from 1990 to 2022 ($n = 318$ fatalities)*.

Number of resident children	
Annual rate of fatal farm injuries	4.7 per 100,000
Fatalities to boys	78%
Fatalities to preschool-aged children (< age 6)	53%
Fatalities to children of farm operators	70%
Machinery involved	65%
Work involved	71%
Victim working	17%
Top 3 machines involved	Tractors (45%)
	ATVs (13%); Other Motor vehicles (11%)
Top 3 non-machinery causes	Drowning (37%)
	Animal trauma (14%)
	Struck by objects (13%)

*Source: Canadian Agricultural Injury Reporting (9).

products (10). In terms of injury, nationally representative data on the most serious types of farm injury are available from the Canadian Agricultural Injury Reporting program (11), our national system for the surveillance of injuries related to agriculture. Available data include reports from 1990 to present on fatalities related to agricultural work and settings, including those involving children (Table 1). Trends and patterns within these fatality records are informative. Overall, while annual counts and number of children at risk have declined as the agricultural sector has changed, on a per capita basis the risks to farm children have remained fairly constant over the past three decades (11). The majority of child fatalities are experienced by boys who are residents of farms. Most involve machinery, primarily tractors due to runovers and rollovers, with emergent risks associated with ATV operation (11). Preschool-aged children (11, 12) and young workers (6) are particularly vulnerable, especially when assigned to situations and tasks that they are developmentally incapable of handling (13–15), and with inadequate adult supervision (16). This situation has persisted for generations on Canadian farms, and while much has changed due to advances in work and technology (8), much remains the same.

Child farm injury in Canada: Some perspective

Tradition, culture and economic demands within farm populations are important factors in understanding why children continue to be exposed to farm hazards and associated risks for injury. Farming in North America in many ways is a unique occupation. Farm operators balance the need to keep themselves, their families and their workers safe from occupational hazards while simultaneously trying to pass on important values within their families, and while trying to maximize productivity and associated financial returns in the face of economic uncertainty (17–19). Consequences of this situation are well understood. Positively, children are intentionally exposed to situations that put them at risk to promote the values of hard work and autonomy, to advance their growth and development, and to foster strong ties between generations of families (18). All of these are good. More negatively, these values and practices can also lead to an acceptance of risk for children and young workers that is problematic, because it leads to the fatalities described above (11, 12, 16). Solutions to the injury problem on North American farms are unlikely to be effective if imposed from government or industry without the direct involvement of farmers. Farmers have historically resisted occupational health and safety regulations as an affront to their autonomy (19–21). What is valued culturally by most of the Canadian farm community often is in conflict with best practices for prevention from the public health, clinical and health and safety communities. This is an important challenge for health and safety efforts.

Prevention strategies: The evidence base

In this commentary, we have drawn upon available systematic reviews (21, 22) to describe what is known about the effectiveness of various strategies to prevent injury on farms. There are few randomized trials or other sophisticated evaluations of different strategies to prevent child injury on farms available in the scientific literature. The most widely accepted strategies are educational in nature, and these tend to be effective in making people aware of hazards, but with limited demonstration that they ultimately change rates of major trauma. Engineered solutions are also common and effective, but not universally adopted due to very real considerations of cost and the challenge of regulating occupational worksites that are autonomous and geographically dispersed. Policy solutions (referred to as "regulations" or "enforcement" in the injury prevention literature) too are available *via* occupational health and safety legislation applying to child labor practices (16) and highly effective when enforced (16). Yet, such legislation sometimes does not apply to resident farm children, nor does it cover situations where children are brought in to the workplace when adults are working, a circumstance common to many child fatalities (11, 12, 16).

Barriers to implementation of effective prevention strategies: An honest reflection

The prevention of traumatic injury on farms and ranches remains a major challenge. In the development of this commentary, front-line agricultural safety and health practitioners associated with the Canadian Agricultural Safety Association were consulted to seek their expertise on barriers to the implementation of safety strategies that are known to be effective in other industries. A summary follows.

Agricultural work contexts are thought to be unique. The motivations and passion behind these agricultural businesses are steeped in tradition (19, 20) and are often not motivated solely for financial gain—for the most part, people are farming and ranching because of the lifestyle and passion for the occupation. Many farms and ranches are also the location of family homes, meaning there is a mix of "workplaces" and "play places".

> "*It's a deeper question than just covering regulations – it's a mind-set. Separating work from family on the farm becomes blurred when the workplace is also a living space and a playground.*" Canadian Agricultural Safety and Health Practitioner (Anonymous), 2022.

Engineered solutions, including the maintaining of equipment and structures, and the creation and maintenance of safe play areas (23) are considered vital, but can be expensive. Education solutions, including teaching producers about age-appropriate work (24), and children and youth from a young age about health and safety (25) are similarly held in high regard. Policy solutions like daycare (20, 21), farm safety audits (8), regulatory enforcement of child labor practices (5), and (although not studied in detail) financial incentives to improve farm safety (26) may be most effective, but can be divisive. In practice, there is considerable support for self/farm family-driven solutions (e.g., self-directed safety audits; grassroots childcare initiatives). There is considerably less support for imposed solutions like regulatory enforcement.

> "*In general, the introduction of legislation is always overwhelming for farm businesses. Farms have a tremendous amount of regulatory and administrative burdens, which are identified as one of the primary stressors contributing to mental health challenges in agriculture.*" Canadian Agricultural Safety and Health Practitioner (Anonymous), 2022.

Final thoughts

Traumatic farm injuries to children remain an important public health problem in Canada. Producers, communities, and agriculture-based organizations in our country, including safety and health organizations, do embrace keeping children and youth safe. Farm families in Canada are acutely aware of hazards associated with farm life and make adjudicated decisions to balance the risks and benefits of intentional farm and farm work exposures (18). Moreover, there is agreement that it is important that the sustainability of family farms and ranches is supported, and this includes protecting farm families.

Solutions are complex and are ultimately influenced by tradition. Ultimately, the prevention of injuries to children on Canadian farms will necessarily involve a culture change, including a shift in the narrative on how children and youth live and play on farms and ranches, with the support of evidence-based education, engineering and policy solutions. This remains an ongoing challenge for all concerned.

Author contributions

WP prepared the initial draft of this manuscript. AL and RA surveyed agricultural safety professionals from across Canada in order to summarize their insights about the prevention of injuries to children on farms. KB, AL, RA, and DV reviewed and edited the manuscript for important intellectual content. DV and KB oversaw the analysis that underlies this commentary. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Utilizing the Delphi method to develop parent and child surveys to understand exposure to farming hazards and attitudes toward farm safety

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Children on farms are at increased risk of injury. In Australia, children under 15 years consistently represent ~15% of all farm-related fatalities. This study aimed to develop parent and child surveys to gain a greater understanding of children's (5–14 years) exposure to occupational risk on farms by exploring their exposure to farm hazards, risk-taking behavior, their use and attitudes toward safety measures, and experience of farm-related injury. As farming communities are heterogeneous, a modified Delphi method was undertaken to ensure input from a diverse group. Seventeen experts participated in a three round process—the first two rounds required rating of proposed survey questions in an online questionnaire and the final round was an online discussion. Consensus was defined as 75% agreement or higher. This process resulted in 155 parent questions and 124 child questions reaching consensus to include. The modified Delphi method developed surveys that provide insight into the behaviors and attitudes of children (individuals) and their parents on farms (family) and will assist in informing how community, organizations and policy frameworks can improve child safety on farms. It will assist in identifying and understanding common farming exposures/behaviors of children and their parents to inform the development of targeted and culturally appropriate injury prevention strategies. As farming groups are heterogeneous, these survey scan be used on varying farming cohorts to identify their unique farming hazards and challenges. Child farm-related injuries are a problem globally and must be addressed; children are dependent on adults and communities to create safe environments for them.

KEYWORDS

Delphi technique, child, parent, risk-taking, agriculture, farms, Australia, attitude

Introduction

Globally, children on farms have been identified as vulnerable to injury. In Australia, children represent ~15% of farm-related fatalities; a rate that has remained consistent for over 20 years (1). The key hazards responsible for these deaths are; water bodies, quad bikes, tractors, utility vehicles and cars, motorbikes and horses (1).

While consistent rates of farming injury—and the hazards contributing to injury—are well identified, children's behavior on farms and how they engage with farming hazards is not well understood. Internationally, some research has explored the individual aspects of children's exposure to the farm, including their risk, use of safety measures or farm tasks completed (2–8). Research conducted in Australia has explored fatal injury associated with specific farming hazards, such as water bodies and quad bikes (9, 10). However, much of what is known about behaviors on Australian farms remains anecdotal. To our knowledge there has been no surveys previously developed that sought to investigate children's engagement with the farm, targeting known key hazards, use of safety measures, attitudes toward farm safety and role on the farm.

The farming workplace is frequently also a place of residence and an embedded part of farming family lifestyle, culture and values. As such, children will always be involved in agriculture to some degree. While agriculture remains one of the most dangerous industries in Australia (11), it is imperative to understand how children's engagement can be managed and integrated in the safest way possible.

Shifting culture and patterns of behavior that may have been established over multiple farming generations requires a "whole of community" approach (12, 13). The socio-ecological model (SEM) considers how factors influence individuals' behaviors. Specifically, it highlights the interaction between the individual (intrapersonal), relationships (interpersonal), community and societal factors (14). Understanding how these factors interact and influence the safety of children on farms is important to facilitate behavior, cultural and legislative changes.

Community engaged research has been identified as a tool able to empower communities through inclusion, collaboration and participation. Participatory research can occur on many levels from "inform" where stakeholders are informed on a certain topic, through to "empower" where the community leads the research project (15). There are many benefits to participatory research, including benefits for the community (capacity building and shared decision making) (16); greater relevance and cultural sensitivity of research; greater participant recruitment; and, improved reliability and validity of research outcomes and translation of research findings (17, 18). A valuable tool for community engaged research is the Delphi method (17). The Delphi method was developed by the Research and Development Corporation (RAND) in the 1950s (19, 20). Typically, the multistage technique focuses on gaining consensus from a group of experts on a particular subject (21, 22). While the process has evolved over time, it continues to be based on two fundamental characteristics: (i) a series of iterative rounds where expert panelists provide their opinion, and (ii) the results of each round being shared with panelists before they provide feedback in the next round (23). Based on these fundamental characteristics, the Delphi method allows for flexibility to ensure the process is suitable and appropriate for the aims of the study and the panel of experts recruited (21).

Most research to date that has explored children's engagement with the farm has gathered information from the perspective of the parent. Ehrlich and colleagues (24) matched parent and child surveys on their knowledge, habits and attitudes around safety behaviors, concluding it was inaccurate to rely on parents' responses on their children's use of safety measures, as they overestimated their use. The results also showed a strong association between parents' role-modeling positive safety behaviors and reduced risk-taking by children. This highlighted the need and benefits for injury prevention to be a whole family issue. Therefore, it was deemed important to develop two surveys to gain insight from both parents and children to develop a more holistic understanding of risk-taking behaviors and use of safety measures on farms.

The aim of this study was to utilize a modified Delphi method to develop community-informed parent and child surveys to measure children's exposure to farming hazards, their risk-taking behaviors and experience of farm-related injury, and their use of—and attitudes toward—safety measures. The purpose is to describe a method that can be used by others to develop surveys specific to their country.

Materials and methods

The Delphi method: Overview

The modified Delphi method used in this study

The Delphi method was used in this study to develop a set of survey questions to explore children's exposure to farming hazards, risk-taking behaviors, use of safety measures and experience of farm-related injury, from the perspective of parents and their children (aged 5–14 years). As such, the following modifications to the traditional process were implemented.

1. Literature review: Traditionally, a single open-ended question would have been asked of panelists in the first round of the Delphi method. In this study, a review of the literature was undertaken to inform the development of a series of proposed closed-ended questions to undergo rating by the panel. This has become a widely accepted modification (25).
2. Rating scale: A five-or nine-point Likert scale is typically used in rating items *via* the Delphi method. In this study, the panel were asked to rate the proposed questions as either "yes" (to be included in the final survey), "no" (to be removed) or "unsure or needs further editing" (26, 27). This meant panelists had to make more definitive decisions with their rating of proposed questions.

3. Anonymity of the panel: Traditionally, Delphi panels remain anonymous to each other throughout the whole process. This is largely to avoid bias and potential influencing on decision-making. However, more recently, the combination of anonymous rounds and a subsequent face-to-face discussion have been successfully used (26, 27). The current three round study consisted of two rounds requiring panelists to complete online surveys (anonymous to other participants) and the final round held as an online discussion. This allowed all panelists to come together to discuss and clarify the remaining questions that were yet to reach consensus after the first two rounds. However, rating of the remaining questions was still completed anonymously.

There were benefits for utilizing a modified Delphi method to develop the two surveys. Previous research has described consensus as a reliable contingency and acceptable to achieve construct validity (28). Hutchings and colleagues (29) determined the Delphi method to be more reliable than nominal groups in using consensus in the development of clinical guidelines. Additionally, the use of the Delphi method allowed a group of experts and end-users from various geographical locations to assist and be involved in the development of the two surveys (30). This resulted in panelists being consulted and involved throughout the development of the surveys ensuring a participatory research process (15). The modest number of participants required allowed the study to be conducted with the limited resources available (31, 32). Utilizing the mixed methods of panelists rating questions on inclusion and providing qualitative responses allowed for thorough feedback and consideration of each proposed question. The online discussion of the remaining questions ensured all panelists could raise their uncertainties. Further, maintaining anonymity of individual panelists rating throughout the process ensured they could be comfortable providing their opinions and not be influenced by others which may have occurred if a focus group was utilized (e.g., dominating personalities or people they may identify as superior) (30). The providing of result reports following the first and second rounds allowed panelists to see how others were rating the proposed questions and the comments provided, this allowed them to reflect and potentially adjust their rating in the following rounds.

Ethics approval was obtained from Deakin University Research Ethics Committee (Ref: 2020-355).

Panel selection and recruitment

There are no specific guidelines on who or how many participants to include in a Delphi panel. Each participant must be justified as a topic expert and the panel should represent variation in cognition, expertise and experience (21, 22, 26). Therefore, multidisciplinary experts with varied experience (agriculture, health, research, farming parents, and policy development) from varying geographic locations (across Australia and internationally) were invited to participate.

Potential panelists were identified through a combination of purposive and convenience sampling, drawing on the direct and extended networks of the National Center for Farmer Health (25). These included child farm safety specialists, injury data experts, child farm safety educators, farm safety researchers, farming parents, rural health researchers, agricultural industry and government representatives, and medical professionals. In total, 27 professionals were invited *via* email to participate, resulting in 17 consenting to participate in round one (see Table 1 for description of panel participants).

Panel retention has been highlighted as a key aspect of a successful Delphi method (21). The research team encouraged panel retention by: (i) providing a brief description of the overall process so panelists were aware of the total commitment required, (ii) ensuring that those who were invited to participate had a demonstrated interest in the safety of children on farms, (iii) ensuring the process was undertaken in a short time frame, and (iv) encouraging a sense of panelist ownership over the survey development by creating each round from the results of the previous round (21, 26, 33).

Consensus

The Delphi method relies on agreement between participants. This "consensus" is defined as the minimum acceptable percentage of agreement between panelists. Literature suggests it is crucial to predefine the level of consensus for a study (21, 26, 33, 34). However, there are no consistent guidelines for determining consensus. Previous literature has suggested varying levels of consensus. Nair et al. (33) recommended between 70 and 80% agreement is appropriate, Niederberger and Spranger (22) endorsed over 60% consensus. Jimenez-Garcia et al. (35), Woodcock et al. (36) and Keeney and colleagues (37) all suggested 75% agreement as appropriate in determining consensus. In the current study, consensus was set at 75% or higher agreement.

The three round modified Delphi method

Round one: Initial rating of proposed questions

Figure 1 demonstrates the process undertaken in this modified Delphi method. Round one required the 17 panelists to rate proposed questions developed from a review of the literature exploring injury and safety of children on Australian farms (38). The questions developed were a combination constructed by the research team aiming to target the themes and gaps in knowledge identified in the literature review. Where possible, questions that had been used in previous research were utilized (6, 7, 39–45). During

TABLE 1 Panel participants in the modified Delphi study.

Participant	Location	Organization/role	Number of rounds completed
1	Melbourne, Victoria	Agriculture peak body/advocacy group	3
2	Sydney, New South Wales	Government department representing agriculture	3
3	Leongatha, Victoria	Emergency services	3
4	Geelong, Victoria	Farming parent and University researcher	3
5	Kergunyah, Victoria	Farming parent	3
6	Wisconsin, US	Child agricultural health and safety organization	3
7	Melbourne, Victoria	University injury surveillance unit	3
8	Derrinallum, Victoria	Farming parent and child farm safety educator	3
9	British Columbia, Canada	Agricultural health and safety organization (not for profit)	3
10	Hamilton, Victoria	University researcher	3
11	Brisbane, Queensland	Farm safety organization/advocacy group (not for profit)	3
12	Melbourne, Victoria	Child accident prevention organization (not for profit)	3
13	Melbourne, Victoria	Government Department representing health	3
14	Dubbo, New South Wales	University agricultural health and safety center	2
15	Melbourne, Victoria	University accident research center	2
16	Iowa, United States	Agricultural health and safety organization (not for profit)	2
17	Melbourne, Victoria	Workplace health and safety regulator	1

question development, all levels of the SEM model were considered including individual (e.g., child demographics); relationships (e.g., the behaviors of those closest to the child including parents); community (e.g., the physical and social environment including the safety measures in place on the farm); and, societal (e.g., cultural norms/influences including what factors influence where children are allowed on the farm) (14). Exploring how these factors interact and influence the safety of children on farms is important to understand behavior and consequently how to influence behavior change.

Questions underwent a pre-Delphi piloting process where a selection of parents ($n = 7$) and their children (within the survey age range of 5–14 years) were asked to provide feedback on question comprehension, wording and overall survey. This ensured the questions presented to the Delphi panel in round one were suitable for the study's target audience. The proposed questions were formatted as an online survey using Qualtrics with questions split into those targeting parents and those for children. Panelists were asked to rate each proposed question using a three-point scale; "yes" (to be included in the final survey), "no" (to be removed), or "unsure or needs further editing". They were able to provide comments on their decisions, which were then themed and utilized in round two of the process. The three-point scale meant panelists had to make more definitive selections, therefore, assisting in more immediate consensus (33).

Analysis was conducted after each round using the Statistical Package for the Social Sciences (SPSS) (version 27). The percentage agreement on each question was calculated. Agreement of 75% or higher for "yes" or "no" was deemed consensus and the question was removed from future rounds (25, 34, 36). The qualitative comments were grouped per question; the comments on the proposed questions that had not reached consensus to keep were analyzed and alterations were made accordingly. Additionally, new questions were developed from suggestions by the panelists. The altered and new questions were then rated in round two. Result reports were developed for each panel member outlining their individual response per question, the overall panel results and the qualitative feedback (25). Following each round, the result reports were sent to each panelist to allow them to compare their decisions to the overall panel and to see how the survey was being developed from their feedback (21, 22, 30, 33).

Round two: Re-rating of proposed questions

Round two followed the same process as the first round with 16 panelists completing the rating of proposed questions. The Qualtrics survey for this round was developed from the results of the first round. This resulted in panelists re-rating questions that had not yet reached consensus (parent survey $n = 29$, child survey $n = 7$) as well as rating additional questions developed from the qualitative feedback provided (parent survey $n = 26$, child survey $n = 25$) (25, 26, 33, 36). In round one, panelists provided qualitative comments after each question category. During analysis, qualitative comments were themed—this included collating comments about each proposed round one question and any additional comments/question suggestions for each question category group. Where deemed

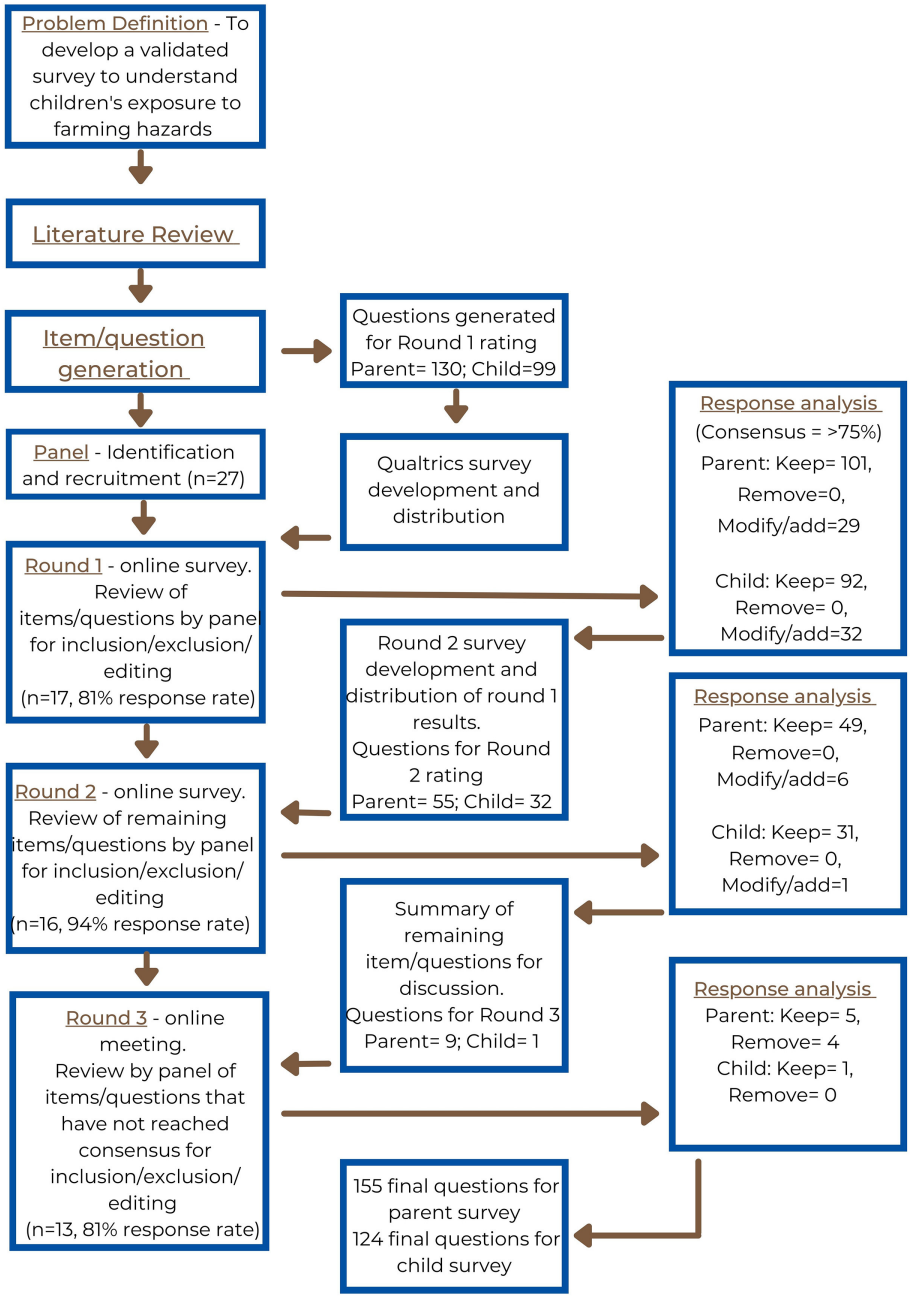

FIGURE 1
The modified Delphi method utilized in this study (25).

appropriate by the research team (i.e., where there was a gap in the proposed questions and where this was considered within the scope of the study), the proposed new questions were then added to the next round of rating, or the wording of previously proposed questions was altered, or multiple choice options were added in previously developed questions. An example of a new question added to round two for rating was "does your child engage with other farming hazards?" This question was developed following panelist feedback on the need to explore other possible hazards. An example of an amended question seeking a more specific understanding was "are there factors you take into consideration when deciding what areas of the farm your child is allowed to go to?" This was amended from "what contributes to your decision to allow your child into the farm workplace?" Rating was completed using the same three-point scale as the previous round. Analysis was conducted in the same way and result reports were disseminated to panelists.

Round three: Discussion to reach final conclusions on proposed questions

The final round was held as an online face-to-face Zoom discussion with the aim of reaching efficient consensus on the remaining questions. Until this point, the panel had been anonymous to each other. This modification to the traditional Delphi method has become more common with Boulkedid and colleagues (26) suggesting more than half of all Delphi studies in their systematic review had at least one meeting of panelists. Thirteen panelists attended the online meeting. Each of the remaining questions were presented to the panel (parent survey $n = 6$, child survey $n = 1$) as well as three additional questions for the parent survey, these were all discussed and then rated. The rating of questions was altered slightly from the previous two rounds—panelists were asked to rate questions at the time as either "yes" or "no"—the "unsure" option was removed as panelists could raise their uncertainties and discussion could take place, this was to ensure consensus was achieved by the end of the round. The online program Mentimeter was used for live voting as it ensured rating was still anonymous. If consensus was not reached, further discussion was held and amendments to the question were made before rating was completed again until consensus was reached. Questions that reached consensus to be removed in this round were the disclaimer statements (e.g., "certain authorities" state that children under 16 are not to ride on or operate quad bikes) added in to round two following feedback from some panelists. However, comments provided by other panelists and discussion within the research team highlighted the influence these statements could have on parents answering the survey, resulting in bias. Following discussion in this round, it was agreed that these would be removed.

Following the final Delphi round, the two final surveys were developed in Qualtrics with all questions that had reached consensus to be included. A final review was then conducted by the research team to assess the questions and survey flow/logic, minor alterations and removal of redundant questions was completed.

Results

Delphi method for the development of the parent survey

Table 2 demonstrates the results by each round of the Delphi method to develop the parent survey. In the first round, the 17 panelists rated 130 proposed questions, 78% ($n = 101$) of which reached consensus to include in the final survey and 22% ($n = 29$) did not reach agreement. No questions were removed.

The second round consisted of questions that had not reached consensus in the first round, along with additional questions/altered questions following analysis of the qualitative comments. The main themes arising from panelist comments included (i) the need to remove open ended questions and provide multiple choice options, (ii) alterations in question construction and wording, and (iii) the need to focus questions on the key hazards causing child injury.

Of the 55 questions rated, the 16 panelists reached consensus to keep 89% ($n = 49$) of the questions and 11% ($n = 6$) remained unresolved.

The online discussion resulted in 13 panelists coming together to discuss the remaining questions. Five (56%) were kept and four (44%) were removed from the final parent survey.

Delphi method for the development of the child survey

Table 3 demonstrates the results per round of the Delphi method for the development of the child survey. Panel consensus was very high in the development of the child survey questions. Panelists rated 99 proposed questions for the development of the child survey; 93% ($n = 92$) reached consensus to be included in the final child survey and 7% ($n = 7$) remained unresolved. The qualitative comments provided by panelists on the child survey was consistent with comments on the parent survey. Panelists did highlight some questions were too complex for children so small changes were made to make it simpler for children to answer.

Round 2 saw similar results with 97% ($n = 31$) reaching consensus to include and 3% ($n = 1$) remained. The panel reached consensus to keep the remaining proposed question during the online discussion round.

Table 4 provides a summary of results of the Delphi method showing 155 questions reached consensus to be included in the parent survey and 124 for the child survey.

Discussion

The modified Delphi method utilized in this study was effective in developing two surveys to explore children's exposure to farming hazards, risk-taking behaviors, attitudes and use of safety measures, and experience of injury. The mixed method nature of the modified Delphi (including rating and qualitative data) allowed for a more thorough identification of appropriate questions, as well as a greater understanding of panelist reasoning behind the rating choices and the subsequent amending or adding new questions. Furthermore, holding the final (3rd) round as a live online discussion with anonymous ratings, encouraged varying opinions to be shared and allowed all panelists to feel comfortable providing their individual opinions.

The results of the Delphi method highlighted the value and importance of collaboration and participatory research. Although there was >70% agreement in the parent and

TABLE 2 Results of the Delphi method consensus process for the parent survey by round and question category.

Categories of questions	Round one			Round two			Round three		
	Total questions rated by category (*n*)	Consensus reached to keep* (*n*)	Consensus not reached (*n*)	Total questions rated by category# (*n*)	Consensus reached to keep* (*n*)	Consensus not reached (*n*)	Total questions rated by category# (*n*)	Consensus reached to keep* (*n*)	Consensus achieved to remove (*n*)
Demographics	14	9	5	4[a]	3	1	2	1	1
General farm safety	5	2	3	4	4	0	1	1	0
General exposure to farming	13	8	5	6	6	0	–	–	–
Safety measures	13	8	5	7	7	0	–	–	–
Water bodies	4	4	0	4	4	0	–	–	–
Quad bikes/side-by-side vehicles	13	12	1	6	5	1	1	0	1
Tractors	6	6	0	8	6	2	2	1	1
Farm vehicles	5	4	1	5	3	2	2	1	1
Motorbikes	6	6	0	2	2	0	–	–	–
Horses	4	4	0	2	2	0	–	–	–
Other hazards	–	–	–	1	1	0	–	–	–
Child role on the farm	15	11	4	2[a]	2	0	–	–	–
Culture/attitudes on child farm safety	10	7	3	2[a]	2	0	1	1	0
Education	–	–	–	2	2	0	–	–	–
Role-modeling	11	11	0	–	–	–	–	–	–
Child farm injury experience	11	9	2	–	–	–	–	–	–
Total	130	101 (77.7%)	29 (22.3%)	55	49 (89.1%)	6 (10.9%)	9	5 (55.6%)	4 (44.4%)

*Consensus was defined as 75% or higher agreement.
#Includes previous round questions where consensus was not reached plus new questions added.
[a]Questions that were not carried on to the next round were combined with other questions.

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TABLE 3 Results of the Delphi method consensus process for the child survey by round and question category.

Categories of questions	Round one			Round two			Round three		
	Total questions rated by category (*n*)	Consensus reached to keep* (*n*)	Consensus not reached (*n*)	Total questions rated by category# (*n*)	Consensus reached to keep* (*n*)	Consensus not reached (*n*)	Total questions rated by category# (*n*)	Consensus reached to keep* (*n*)	Consensus achieved to remove (*n*)
Demographics	6	6	0	1	1	0	–	–	–
General farm safety	2	2	0	–	–	–	–	–	–
Exposure to farming hazards	8	7	1	3	3	0	–	–	–
Safety measures/farm safety knowledge	15	13	2	2	2	0	–	–	–
Water bodies	5	5	0	1	1	0	–	–	–
Quad bikes/side-by-side vehicles	14	14	0	6	6	0	–	–	–
Tractors	9	8	1	4	4	0	–	–	–
Farm vehicles	7	6	1	5	5	0	–	–	–
Motorbikes	7	7	0	4	4	0	–	–	–
Horses	6	6	0	3	3	0	–	–	–
Other hazards	–	–	–	1	1	0	–	–	–
Child role on the farm	13	11	2	2	1	1	1	1	0
Child farm injury experience	7	7	0	–	–	–	–	–	–
Total	99	92 (92.9%)	7 (7.1%)	32	31 (96.9%)	1 (3.1%)	1	1 (100.0%)	0 (0.0%)

*Consensus was defined as 75% or higher agreement.
#Includes previous round questions where consensus was not reached plus new questions added.

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TABLE 4 Summary table of the Delphi method for each round.

	Parent survey *n* (%)	Child survey *n* (%)
Round one		
Total questions in round	130	99
Consensus to keep	101 (77.7)	92 (92.9)
Consensus not achieved	29 (22.3)	7 (7.1)
Round two		
Total questions in round	55	32
Consensus to keep	49 (89.1)	31 (96.9)
Consensus not achieved	6 (10.9)	1 (3.1)
Round three		
Total questions in round	9	1
Consensus to keep	5 (55.6)	1 (100.0)
Consensus not achieved	4 (44.4)	0 (0.0)
Total questions reached consensus to include in final surveys	155	124

90% in the child proposed questions after the first round of rating, uncertainty still remained in 20% and 7% of proposed questions, respectively. This collaborative/participatory method enabled improvements in the relevance and cultural sensitivity of the surveys (17, 18). The comments and level of disagreement on some proposed questions demonstrates the process rigor. This resulted in improved use of language, additional collaboratively-agreed-upon questions, inclusion of appropriate examples and multiple choice options. While efforts were made to ensure a diverse representation of experts involved in the Delphi, the overall number of participants ($n = 17$) was not large. Consideration for inclusion in the panel included organizational affiliation, experience, academic qualification, geographical location and recommendation by others (22, 31). In a Delphi method, group size does not rely on statistical power and there is no agreed upon minimum number of panelists recommended (31). Rather, the focus is on multidisciplinary representation, differences in cognition, expertise and experiences as well as potential group dynamics (22, 26, 46).

A potential limitation to this study was the high consensus between the panel members in regard to the child survey. It is suggested this may be due to the child survey questions being presented after the adult questions in every round (47). It is not believed this influenced the development of validity of the final child survey as the additional questions introduced in round two were aligned to the results of the parent survey to ensure the two surveys would be comparable. It is recommended in future research that the order of the proposed questions for a survey be changed between rounds, as panelists may fatigue toward the end of each round.

The Delphi method relies on group consensus, and while the panelists that participated in this study were deemed "experts" in the field, there is the potential that the results are not necessarily the most correct, as they are still based on opinion (23). However, when there is no other evidence available, the reliance on group opinion is believed to be a better basis and superior than the dependence on an individual judgement (48, 49). As child farm-related injury rates have remained consistent over an extended period, a new approach is required.

The consensus between panelists to "keep" questions was high, resulting in a large number of questions to be included in the final surveys. As described above, following the completion of the three Delphi rounds, the research team assessed the questions and removed any questions that had become redundant throughout the rounds. Further, survey logic was added to ensure participants were not asked to answer any questions that were not relevant to them, reducing completion time.

Following the development of the two surveys, the parent survey will be promoted throughout rural/regional Victoria for completion. Once a parent completes the survey, they will be emailed a link for their child to complete the survey. It is aimed 100 surveys will be completed in this study.

Conclusion

The survey age range (5–14 years) will facilitate a greater understanding of the different safety attitudes and farm activities that children—of varying ages—are undertaking on farms. Previous international research has described children's engagement on the farm as varying—depending on factors such as age and developmental level (3, 4, 8). Future analysis of survey results, will enable comparisons between different age cohorts to see trends in children's behaviors on the farm as they develop. This should assist in the identification and improvement of age appropriate interventions.

This modified Delphi method supported the development of surveys that can assess the behaviors and attitudes of children (individuals), and their parents (relationships) on farms. This will provide insight on how community, organizations and policy frameworks can interact to assist in the development of effective and appropriate interventions to improve child safety on farms. As farming communities are heterogeneous, these surveys will be able to be used across varying farming cohorts (e.g., geographic or industry) to identify specific challenges/behaviors, and assist in developing targeted and appropriate responses to child safety. The resulting surveys may be used longitudinally—with the ability to track change in industry behaviors and attitudes overtime and evaluate the

effect of any interventions and parental awareness of safety for children on farms.

Child farm injury and fatalities have been consistent and an ongoing global shame for centuries. Children are reliant on the adults around them to provide them with a safe environment. Therefore, more needs to be done to understand the farming life/behaviors of children. This study utilized a modified Delphi method that resulted in the development of parent and child surveys to explore children's exposure to farming hazards, risk-taking behaviors, attitudes and use of safety measures and experience of farm-related injury. The consideration of each of the SEM levels within this study will ensure factors influencing behaviors are identified to assist in developing effective, appropriate and targeted "whole of community" initiatives to address child farm-related injury.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Deakin University Research Ethics Committee (Ref: 2020-355). The patients/participants provided their written informed consent to participate in this study.

Author contributions

JA conducted the data collection, data analysis, and drafting of the manuscript. AK, SB, and JC provided guidance and supervision throughout the study. All authors contributed to the study design, reviewing and editing of the manuscript, and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Promoting childhood farm safety in Ireland

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KEYWORDS

children, farm, injury, safety, young persons

Introduction

Preventing injury to children and young persons related to farm work has been a priority in Ireland since the enactment of the Safety, Health and Welfare at Work Act, 1989 (SHWWA.1989) (1). Under this legislation a person in the age category of 0–18 years old or still at school are considered a child or young person and in this paper are described as a child (ren/hood). The Public Health Model of injury causation conceptualizes an injury occurrence as being due to multiple interacting physical and human factors, while the Social-Ecological Model enhances this model by defining various levels of the social and physical environment influential to persons' occupational safety and health (OSH) (2). Farms internationally are mainly small scale, with a wide range of hazards and associated risks and are dispersed throughout the countryside (3). Thus, promoting childhood safety represents a particular challenge for regulators and farm organizations. This paper describes the following related to childhood farm OSH in Ireland: (a) the socio-economic background of farming of relevance to children; (b) the legislative background; (c) trends in childhood farm injuries; (d) promotional activities with particular reference to current initiatives. The paper finishes with a discussion and conclusions section based on information presented in this paper.

Farming in Ireland

Ireland currently has 130,216 farms with 276,000 persons employed, 73% of whom are male (4). Farming is the sole occupation of 53% of farm holders while average farm size is 32.4 hectares (80.1 acres). The average age of farm holders is 57.2 years with dairy farmers having a younger average age (52 years). Farmer age structure is skewed, with just 7.4% being aged under 35 years and 32.9% aged 65 years and over. Farm enterprise distribution varies throughout the country (5), with, beef (74.2 k), dairy (15.3 k), sheep (17.4 k) and tillage (4.6 k) along with mixed enterprises and "other" including equine, horticulture, pigs and poultry (15.0 k) being the main enterprises (4).

Farm incomes in Ireland are monitored by the National Farm Survey conducted by Teagasc (6). In 2020, average farm income was highest for dairying (€74.2 k), followed by tillage (€32.1 k), sheep (€17.9 k), beef production (€15.0 k); beef rearing (€9.1 k).

Farm income varies annually but the relativities for 2020 are typical. A farm household income may be higher than farm income as in many cases off-farm employment and other transfers provide additional income.

Regarding children on farms, the National Farm Survey (7) reported their numbers for various age categories from 0 to 19 years (Table 1). Overall, 40.1% of farming families have family members in this age range with dairy farms (50.6 %) having the highest proportion followed by tillage farms (40.34%), beef production (36.7%), beef rearing (32.2%) and sheep farming (28.6%).

Labor input varies among enterprises with dairying having the highest workload on average. Farm Infrastructure is an important safety issue related to childhood safety. Generally farm dwellings are located adjacent to the farmyard where much of the farm work and the majority of farm workplace injuries take place. No or limited physical segregation occurs between farm dwelling and farmyard area on many farms.

Employment of migrant workers employed on Irish farms is limited (5.6%), this occurs predominantly on horticulture enterprises and larger scale dairy farms (8). Childcare is available in Irish rural areas, however specific challenges with its provision have been reported. These include low population numbers which impacts on income generation from the service and inaccessibility of training events for staff (9).

Legislative background

Since the enactment of SHWWA 1989, the agriculture sector, including farms with self-employed holders, has been regulated and OSH has been promoted. The 1989 legislation was updated by enactment of the SHWWA 2005 (10). The principal features of the legislation, described in a previous paper (11) include: allocation of legal duties, establishment of a state agency the "Health and Safety Authority" with statutory powers to implement, promote and enforce the legislative requirements. Under Irish SHWW legislation duty holders must implement measures to protect the OSH of persons at work and also "other persons affected by work activity," which includes children.

The legislation also provides a statutory means to enact regulations and codes of practice (COP). Regulations specify precise legal duties and requirements while a statutory COP provides authoritative guidance but permits discretion to adopt equivalent effective measures. Both specific SHWW regulations (12) and a COP (13) related to children, described in section 4 of this paper, are in place in Ireland.

Abbreviations: COP, Code of Practice; FFWi, Fatal Farm Workplace Injury; OSH, Occupational Safety and Health; SHWWA, Safety, Health and Welfare at Work Act.

SHWW (general application) regulations (14) include a requirement to report work related fatal or non-fatal injury which require medical attention or being out of work for "more than 3 days". Reporting is also required for injuries to persons not a work, including children, who are injured due to work activity or the place of work. The implementation of these requirements, in practice, described in a previous paper (15), indicates that fatal farm workplace injury reporting works effectively in contrast to non-fatal injury reporting. Thus, data on children fatality trends is available to give a metric of progress over time.

SHWW legislation also enables statutory consultation with key stakeholders of a work sector, such as farming, and the current statutory advisory committee for the agriculture sector is known as the Farm Safety Partnership. This body has published a Farm Safety Action Plan (2021–2024) which includes goals related to OSH of children on farms (16). Producing recommendations and promotional strategies based on current research for farm children's safety, health and well-being predominate among these goals. This plan mandates stakeholder organizations to implement OSH promotional measures within their sphere of influence.

Codes of practice related to farm childhood and young person safety

As stated, a specific statutory COP for children SHWW on farms is in place in Ireland (13). This is a legally updated COP following-on from a previous one issued after the enactment of the SHWWA 1989. This COP gives guidance on achieving OSH of children on farms. Additionally, a Farm Safety COP giving guidance on overall farm OSH including children has been in place since year 2006 (17) and has been updated in year 2017 (18). COP documents are written for adult farmers who are advised to check and follow the codes when considering work activities related to children.

The 2017 Farm Safety COP is accompanied by a Risk Assessment Document (RAD) (19). This document assists farmers to manage OSH by providing hazard assessment templates for completion for specific farm hazards (both physical and behavioral), including childhood hazards, along with an action list for controls required but not in place. Previous research reported limited identification by farmers of hazards for 'children and older farms' (1.4% of total) for the 2006 RAD, but that childhood OSH conditions were satisfactory on 94.1% of farms assessed where children were present (36% of farms) (11). Further Irish research indicates that farmers gave little prominence to childhood safety (2).

TABLE 1 Percentage of children/ young persons in age cohorts per enterprise on Irish farms.

	Age category (%)			
	<5	**5–15**	**16–19**	**Total**
Farming families ($n = 896$)	**5.7**	**18.1**	**16.2**	**40.1**
Enterprise (n, %)				
Dairy (314, 35%)	7.0	24.5	19.1	50.6
Tillage (72, 8%)	5.6	20.8	13.9	40.3
Sheep (126, 14.1%)	2.4	11.1	15.1	28.6
Beef - Rearing (152, 17%)	5.9	14.5	11.8	32.2
Beef - Production (218, 24.3%)	5.5	1 5.1	16.1	36.7
Other (14/1.6%)	7.1	7.1	21.4	35.6

Fatal farm workplace injuries to children in Ireland

Data for fatal farm workplace injuries (FFWI) indicates that 10% ($n = 21$) of total occurred to children up to age 18 years for the 10-year period to 2020 (20). An occurrence has been reported of 12% ($n = 24$) and 21% ($n = 38$), respectively for the 10 years to 2015 (18) and 2005 (17). Thus it is apparent that fatal injuries to children has reduced by 45% since the 10-year period to 2005. However, as the denominator data on number of children on farms is unavailable, accurate calculation of fatality rates is not possible (21).

The most recent H.S.A data indicates that tractors, farm vehicles and machinery have been associated with most children FFWI's (85%), while drowning/asphyxiation, falling objects and electrocution each accounted for 5% of deaths (22). Half of FFWI's to children occurred to those under 7 years of age. Previously, in 2006, it was reported that tractors and machinery (58%) and drowning (21%) were associated with childhood FFWI's (17). Thus, the association between children FFWI's with farm tractors and machinery has become a more predominant factor over time.

Promotion of childhood farm safety

Media is a powerful tool to communicate safety messages to a large and diverse farmer audience (20). Given the relative importance of the farming sector in Ireland and the close links of the population generally to farming, a vibrant farming media exists in Ireland. This media includes national TV, radio, print and social media, while messages emanate from a wide range of organizations. Media reporting includes fatal injuries reporting, H.S.A. posts and alerts and state and farming organization media releases. Media facilitates rapid and on-going transmission of messages to the farming population related to children safety.

A considerable array of educational promotional booklets and eLearning materials for children are available in Ireland. Such materials are available from both the public e.g., H.S.A (23) and private sector organizations. An example of a private venture is "Agrikids" set-up and operated by farming mother Alma Jordan, who previously worked in marketing. Agrikids provides motivating childhood safety services for the media, schools and events (24). As a further example, an Irish private sector organization, "Agri Aware," which promotes awareness of the value of the agriculture sector, operates a "Farm Safe Schools" educational initiative (25) for primary schools for children aged 4 up to about 12/13 years. Children and young person OSH is also included in secondary school and 3rd level agricultural education syllabi.

Discussion and conclusions

This paper outlines the measures in place in Ireland to promote childhood safety among both adult farm family members and children which are supported by statutory legal provisions. Considerable promotion of childhood safety has taken place for over 30 years and is on-going. It has been shown that children in addition to being positively influenced by OSH promotions can positively influence the attitudes of adults also (26). However, farmers conduct low levels of formal risk assessment related to childhood OSH. Numerous organizations are engaged in promoting farm childhood safety at various levels, in line with the Social-Ecological Model (2). Data available on childhood FFWI's indicates that their level has declined both in numerical terms and as a proportion of total FFWI's. However, on-going research and promotion is needed related to childhood farm OSH, to enhance progress.

Author contributions

JM conceptualized, drafted the manuscript, and revised manuscript. PG and MM reviewed manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Regional surveillance of medically-attended farm-related injuries in children and adolescents

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Purpose: Due to numerous environmental hazards such as heavy machinery and large livestock, youth who live and work on farms are at high risk of injury, disability, and death. This study described a regional surveillance system for monitoring farm-related injuries in children and adolescents. As the risk of farm-related injuries are not exclusive to farm residents, trends in farm-related injuries over the previous 5 years were reported and compared between children/adolescents who did and did not live on farms in north-central Wisconsin.

Methods: A retrospective cohort of child and adolescent patients of the Marshfield Clinic Health System was assembled. Incident farm-related injuries, including from agricultural work or other activities in a farm environment, were extracted from medical records from 2017 through 2021. Generalized linear models were created to compare age- and sex-adjusted farm-related injury rates by year.

Results: There were 4,730 (5%) in-farm and 93,420 (95%) out-farm children and adolescents in the cohort. There were 65 incident farm-related injury cases in the in-farm group and 412 in the out-farm group. The annual incidence rate of farm-related injuries was higher in the in-farm group, but changes during the 5-year timeframe were not significant in either group. In the in-farm group, rates ranged from a high of 61.8 [95% confidence interval (CI): 38.3, 94.5] incident farm-related injuries per 10,000 children/adolescents in 2017 to a low of 28.2 (13.5, 51.9) injuries per 10,000 children/adolescents in 2018. In the out-farm group, rates ranged from 10.7 (8.3, 13.6) to 16.8 (13.7, 20.5) incident farm-related injuries per 10,000 children/adolescents per year between 2017 and 2021. The in-farm group had a higher proportion of injured males and heavy machinery injuries, while the out-farm group had more all-terrain vehicle injuries and pesticide poisonings.

Conclusion: Farm residency remains hazardous for children and adolescents, as injury rates were three times higher in the in-farm group and remained stable

over 5 years. All-terrain vehicle injuries were high in both groups, and should be a priority in rural safety interventions. With additional adaptations to other states, this surveillance model could be scaled across other healthcare systems.

KEYWORDS

agriculture, injuries, children, surveillance, USA

Introduction

At approximately 23 fatal injuries per 100,000 workers per year in the U.S., agriculture, forestry, and fishing consistently have the highest rates of occupational fatalities of any industry sector (1). Fatalities also occur in children and adolescents who live and work on farms (2, 3). Estimates are dated, but 893,000 youth under age 20 lived on farms as of 2014, with roughly half performing work duties and an additional 260,000 youth farm employees, meaning over 1 million U.S. children and adolescents have at least some regular level of exposure to farm hazards (4).

Farm family members live in a hazardous environment that is focused on agricultural production, thus the burden of injuries is prodigious (5). Young workers (regardless of whether they live on a farm or not) are eight times more likely to die from farm work as compared to all other industries combined, and over half of youth injured on a farm were not actually working at the time of their injury (6). All-terrain vehicles (ATVs), for example, are a primary cause of farm-related injuries in children and adolescents (7), and an estimated 12% of farm-related injuries appearing in news media reports are due to heavy machinery such as skid steers or augers (8).

Little is known about recent trends in farm-related injury risks, however, because the U.S. lacks a comprehensive surveillance system. National farm injury estimates are particularly limited after 2015 when federal occupational health agencies suspended farm-related injury surveillance activities. There may be some positive developments, as the absolute number of pediatric visits to emergency rooms for agriculture-related injuries in the U.S. has declined by over 40% since 2001 (9, 10). This seeming improvement may be driven by the declining numbers of farm households though, as fewer youth actually live or work on farms in the U.S. today (11, 12). As such, youth's relative risk for farm-related injuries remains unclear. This underscores the critical need for reliable, simultaneous capture of both injuries and time at risk when assessing farm-related injury trends, particularly for priority populations like children and adolescents (13). Leaders of agricultural safety organizations have identified farm-related injury surveillance as a top priority to help evaluate safety initiatives (2, 14–16).

The burden of farm-related injury is not exclusive to youth who live on farms. Such injuries, perhaps about one-third, have also been shown to occur in adolescents who work on a farm or in young children playing on a friend's or family's farm (17, 18). For example, nearly 25 million youth visit farms in the U.S. annually, with nearly all of them being repeat visitors (19). As might be expected, one study in Alberta, Canada observed the relative risk of farm-related injury was far greater in children and adolescents who live on rural farms as compared to their urban non-farm counterparts (20). Such estimates are not available in the U.S. though. Furthermore, there could be differences in risk depending on the specific type of farm-related injury. Studies with direct demographic comparisons across defined populations are rare though, and farm-related injury risk estimates from the U.S. are dated (19). The purpose of this study was to: (1) describe the Wisconsin National Children's Center for Rural and Agricultural Health and Safety surveillance (WINS) system for regional monitoring of farm-related injuries in children and adolescents, (2) estimate annualized trends in farm-related injuries over the previous 5 years, and (3) compare farm-related injury trends between children/adolescents who did vs. did not live on area farms.

Methods

Design and setting

The source population included child and adolescent patients of the Marshfield Clinic Health System (MCHS) who lived in a 20-county region of north-central Wisconsin during the 2017–2021 timeframe (Figure 1), and who had reasonably complete capture of their medical care within MCHS data systems. MCHS is a large multispecialty system that serves a predominantly rural patient base across small communities in central and northern Wisconsin. As detailed further below, study data was extracted from MCHS's research data repository, which stores medical and administrative information documented in MCHS electronic health records (EHR) from clinical encounters.

Cohort assembly

The analytical cohort included children and adolescents in the source population who: (1) were age 0–17 years for ≥90 continuous days between 01/01/2017 and 12/31/2021, and (2)

FIGURE 1
20-county target population of north-central Wisconsin children and adolescents who did and did not live on a farm in 2017–2021.

had reasonably complete capture of medical care within MCHS data systems as evidenced by: (a) "medically homed" to an MCHS medical center (i.e., $\geq$ 2 preventive or well-child visits over the previous 3 years or an assigned MCHS primary care provider), (b) member of the MCHS-affiliated Security Health Plan (SHP) of Wisconsin, or (c) resident of the Marshfield Epidemiologic Study Area (MESA) (21, 22). Person-time follow-up, or cohort entry, for individuals began on the first day of the month that all eligibility criteria were met within the study timeframe. Cohort end was due to death, out-migration, or reaching age 18 years.

Farm status

Cohort members were stratified by farm and non-farm residency. Children and adolescents with a residential address that had evidence of agricultural production at any point during the 2017–2021 study timeframe were categorized in the in-farm group. Those with no evidence of farm residence during that timeframe were categorized in the out-farm group. To establish farm residency, cohort members' MCHS residential address history was linked to two separate publicly-available farm data sources, including (1) a registry of licensed dairy producers from Wisconsin's Department of Agriculture, Trade and Consumer Protection, or (2) a commercially-available (purchased) listing of agricultural producers (www.dtn.com/agriculture/producer/) specific to the target 20-county region. All study procedures were approved by the MCHS Institutional Review Board, including approvals to waive documentation of informed consent and HIPAA authorization.

Farm-related injuries

The outcome was medically-attended farm-related injuries. A farm-related injury was operationally defined as medical attention received for an energy transfer event that originated from a farm source (e.g., tractor, tool, livestock) while the individual was either in a farm location or engaged in (or observing) farm-related work. Farm-related injuries could be agricultural work or other activities in a farm environment. Efforts were also made to identify recreational activities that took place in the farm location (e.g., riding horses or ATVs). Medically-attended farm-related injuries were ascertained based on adaptations of injury surveillance models outlined by Landsteiner et al. (23) and Scott et al. (24, 25). Injury details were extracted from medical diagnoses observed during emergency, inpatient, urgent care, or outpatient encounters in the MCHS electronic data repository. Said diagnoses typically occurred in MCHS-affiliated hospitals and clinics, but were also ascertained from SHP insurance claims for encounters outside of MCHS (for those with SHP insurance). Specifically, external cause of injury codes indicative of farm accidents have been shown to capture farm-related injuries with excellent specificity (26, 27) and their use has been mandated in medical coding practices in Wisconsin since 1993 (28). Such codes are primarily used for billing as part of the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) system. These codes included Y92.7X and W30.XXX, in addition to several less specific codes (26, 29) that are described in the Appendix in Supplementary material.

Chart review

In the in-farm group, all farm-related injuries identified *via* the electronic case finding logic were subjected to a manual chart review conducted by a trained Research Coordinator. This chart audit included a review of all clinical documentation of the associated medical encounter in order to confirm the presence or absence of a farm-related injury. The Research Coordinator primarily reviewed free-text documents to determine whether the injury occurred while doing or observing a farm activity, related or unrelated recreational activity, or otherwise at a farm location. Chart audits further extracted clinical features of the farm-related injury and documented precipitating circumstances. Approximately 10% of all candidate cases were re-audited by a different Research Coordinator to detect and correct possible interrater discrepancies or inconsistencies. Injury chart reviews have not yet been conducted in the out-farm group due to study budget constraints (thus detailed injury

features were only available in the in-farm group), but chart reviews will be done in both groups as part of future farm-related injury surveillance activities.

Analyses

Descriptive characteristics were reported on the farm and out-farm groups. Differences between injured individuals in the farm vs. out-farm group were also summarized. For the injury trends analysis, new injury episodes were required to be separated by ≥30 days and age- and sex-adjusted incidence rates, with robust 95% confidence intervals (CI), were reported using the direct standardization method based on the 2010 Wisconsin Census population. Incident annual injury rates were modeled using generalized linear mixed models. Analytical procedures were conducted using SAS version 9.4 (Cary, NC).

Results

There were 98,150 unique children and adolescents in the WINS cohort, including 4,730 (5%) in the farm and 93,420 (95%) in the out-farm group. As outlined in Table 1, the two groups were relatively similar across most sociodemographic characteristics, but the in-farm group was slightly older, had more White, non-Hispanic children/adolescents, and fewer with public-assisted health insurance. Across the 2017–2021 timeframe, mean ± SD months of available follow-up (i.e., time under observation) was generally high, and somewhat greater in the in-farm group (43.5 ± 1 8.0 farm vs. 39.2 ± 18.9 non-farm). Annualized person-year contributions were relatively stable in both groups, varying < 10% between years and ranging from a high of 3,554 person-years in the in-farm group and 63,103 person-years in the out-farm group in 2019, to a low of 3,251 person-years in the in-farm group and 58,860 person-years in the out-farm group in 2021.

There were 69 farm-related injuries in the in-farm group [65 (1.4%) unique individuals] and 412 in the out-farm group [378 (0.4%) unique individuals] during 2017–2021. Among the injuries in the in-farm group, all but two were confirmed upon manual chart review. Both unconfirmed farm-related injuries were miscoded as involving recreational vehicles, one having occurred completely outside of the farm environment or during farming activities, and the other not actually involving a recreational vehicle. Inter-rater agreement with chart re-reviews was 100%. Basic characteristics of the incident farm-related injuries are outlined in Table 2, stratified by the in-farm vs. out-farm group. The in-farm group had a higher proportion of injured males. The out-farm group had a different composition of injury types, with more ATV and fewer farm machinery injuries. Most farm-related injuries occurred during summer and in adolescents. Other injury features were only available from chart audits in the in-farm group. The most common injury location was lower extremities (38%), followed by upper extremities (26%), head (22%), and torso (14%). There were no known fatalities linked to patients' farm-related injuries. The vast majority of patients in the in-farm group initially presented to a hospital emergency room (94%). In terms of injury antecedents, 33% were attributed to play or recreation, while 26% were attributed to farm work, and 16% were attributed to transportation. The remainder were unclear from medical chart notes.

As outlined in Figure 2, the annual incidence rate of farm-related injuries was clearly higher in the in-farm group. Changes during the 5-year study timeframe were not significant in either group, but were very steady in the out-farm group, ranging from 10.7 (95% confidence interval [CI]: 8.3, 13.6) to 16.8 (CI: 13.7, 20.5) incident farm-related injuries per 10,000 children/adolescents per year between 2017 and 2021. In the in-farm group, rates ranged from a high of 61.8 (CI: 38.3, 94.5) incident farm-related injuries per 10,000 children/adolescents in 2017 to a low of 28.2 (CI: 13.5, 51.9) injuries per 10,000 children/adolescents in 2018. Incident injury rates were generally stable in the in-farm group since 2018.

TABLE 1 Characteristics of children and adolescents in north-central Wisconsin who did and did not live on a farm in 2017–2021.

	In-farm $n = 4,730$	Out-farm $n = 93,420$
Age (yrs, at cohort end)	12.4 ± 6.1	11.6 ± 5.9
Gender		
Female	2,251 (48%)	45,898 (49%)
Male	2,479 (52%)	47,522 (51%)
Race/Ethnicity		
White, non-Hispanic	4,031 (85%)	72,470 (78%)
Non-White or Hispanic	305 (6%)	13,955 (15%)
Unknown	394 (8%)	6,995 (7%)
Health insurance		
Private	2,353 (50%)	42,609 (46%)
Public-assisted	1,973 (42%)	44,822 (48%)
None	404 (9%)	5,989 (6%)
Number of ambulatory visits (over 5 years)	10.3 ± 13.0	10.2 ± 12.2
Body mass index (percentile categories)		
Obese	786 (17%)	16,370 (18%)
Overweight	699 (15%)	13,625 (15%)
Normal weight	2,521 (53%)	48,923 (52%)
Underweight	199 (4%)	4,637 (5%)
Unknown	525 (11%)	9,865 (11%)
Current smoker	61 (2%)	1,815 (3%)
Chronic medical condition	1,145 (24%)	24,908 (27%)

Values are reported as mean ± SD or frequency (% of total).

TABLE 2 Features of incident farm-related injuries in north-central Wisconsin children and adolescents in 2017–2021, stratified by those who did vs. did not live on a farm.

	In-farm $n = 65$	Out-farm $n = 378$
Age (yrs, at time of injury)	12.0 ± 4.2	12.4 ± 4.4
0–5	9 (14%)	43 (11%)
6–11	20 (31%)	105 (28%)
12–17	36 (55%)	230 (61%)
Gender		
Female	25 (38%)	181 (48%)
Male	40 (62%)	197 (52%)
Season		
Spring	6 (9%)	80 (21%)
Summer	32 (49%)	173 (45%)
Fall	16 (25%)	86 (23%)
Winter	11 (17%)	39 (10%)
Injury diagnosis (external cause)		
Farm-unspecified	18 (28%)	39 (10%)
All-terrain vehicle	17 (26%)	182 (48%)
Animal strike	14 (22%)	98 (26%)
Animal riding	9 (14%)	50 (13%)
Farm machinery	7 (11%)	2 (1%)
Pesticide/herbicide poisoning	0 (0%)	5 (1%)
Other	0 (0%)	2 (1%)
Injury areas		
Lower extremities	25 (38%)	
Upper extremities	17 (26%)	
Head	14 (22%)	NA
Torso	9 (14%)	
Spine/neck	0 (0%)	

Values are reported as mean ±SD or frequency (% of total).

Discussion

The early intent of WINS was to establish a (largely) passive farm-related surveillance methodology in children and adolescents. While limited in scope to north-central Wisconsin, we were able to link available data on farm residency to the medical records of child/adolescent patients of the major healthcare provider in the region. This permitted the subsequent examination of farm-related injuries in the WINS cohort. Results indicated that, over the past 5 years, approximately 40 per 10,000 children/adolescents who lived on farms in north-central Wisconsin experienced a farm-related injury. Though modestly lower since the high point in 2017, incident farm-related injury rates in the in-farm group were statistically indistinguishable between years. This relatively "flat" trend in farm-related injuries was similarly observed in the out-farm group, though, as expected based on prior studies indicating the burden of farm-related injuries is highest in children of farm owners (2, 17, 19), injury rates in the in-farm group were typically three times that of the out-farm group.

Recent data on injury rates in U.S. farm children are sparse, but the risk of farm-related injury in WINS was slightly lower than observed in Alberta, Canada in the early 2000's (20). WINS injury rates were also somewhat lower than the most recent available national estimates of farm-related injury risks in U.S. youth from Hendricks et al. (19). The unit of analysis in that study was farm (vs. farm residents) and injuries were reported by household members, thus some caution is warranted regarding direct comparisons to prior studies with different methodologies. However, under an assumption of 1.5 children and adolescents per farm residence in our target region of north-central Wisconsin (30), the Hendricks, et al. study (based on 2001–2014 surveys) would predict an annualized risk of self-reported farm-related injuries of ∼0.6% in our in-farm group, whereas we observed an actual annualized risk of medically-attended farm-related injuries of 0.4%.

Injuries in our study were more common during summer months, as observed by others (6, 23). Injuries were also more common in adolescents, who presumably had more exposure to agricultural work and/or hazards. Serious injuries to the upper and lower extremities that presented in the emergency room were common, but no fatalities were observed in this dataset. Injury causes clearly differed between the in-farm and out-farm groups. Consistent with prior national estimates (6), farm-related injuries for in-farm children were more balanced across ATVs, animal strikes, and other farm causes. Out-farm children, however, were rarely injured by farm machinery, but were more likely to have experienced an ATV injury. Farming environments are known to be major hazards for children and adolescents in regard to motorized accidents (31), but our findings may also reflect the recent proliferation of non-occupational, recreational ATV use across the U.S. (32). This highlights the need for more effective ATV operator safety training for all youth, and perhaps more restrictive requirements (or enforcement) of ATV operation in those who have not completed safety training. Also of note, pesticide/herbicide poisonings were only observed in the out-farm group, which differed from prior findings by Kim et al. (20). This could indicate increasingly cautious application practices in farm families that are more familiar and experienced with chemical hazards. More applicator training on pesticide exposure prevention may be needed in the general population, including broader efforts to minimize pesticide use and reduce chemical drift (33).

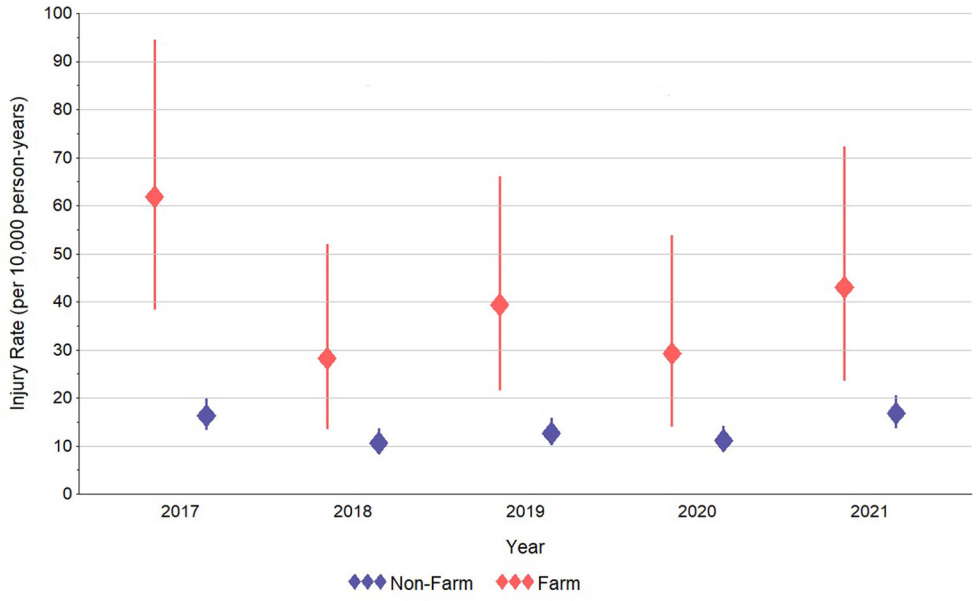

FIGURE 2
Estimated annual incidence rate of farm-related injuries in north-central Wisconsin children and adolescents who did and did not live on a farm in 2017–2021.

Strengths and limitations

Strengths of WINS included the objective EHR and claims outcomes, as well as the population-based sample that reflected real-world patterns of farm-related injuries in north-central Wisconsin children and adolescents. The chief limitation was the retrospective use of medical records to identify injury cases. Individuals with minor injuries who did not receive medical care were not captured, thus incidence rates in this study are likely conservative and err toward more severe accidents. In addition, the target population had a limited regional scope that may be somewhat over-representative of dairy production relative to other parts of the U.S. The in-farm group was based solely on residency, assuming all individuals who lived on an active farm had approximately equal risk. While this assumption was perhaps reasonable given that most Wisconsin farms are still family owned and operated (34), our design did not permit more detailed permutations of risk, such as classifying those who spend more time doing specific dangerous activities, or parsing the out-farm group into those who worked on or regularly visited a farm. Future research could consider more detailed validation of in-farm and out-farm residency in order to help quantify degrees of exposure to agricultural hazards by other related factors such as acreage dedicated to production, volume of heavy machinery, specific farm types (e.g., dairy, crop types), and time spent in farm-related activities, including work and recreation.

Conclusions

Future iterations of the WINS platform will begin integrating other data sources from the state of Wisconsin [e.g., ambulance runs based on models outlined by Scott et al. (24, 25)] to capture more injuries that may have been treated outside of MCHS or not covered by SHP insurance. In addition, chart reviews will be conducted on a sample of farm-related injuries in the out-farm group, and the WINS source population will be expanded by including other healthcare systems that serve children and adolescents beyond north-central regions of Wisconsin. An expanded population will permit identification of subgroups where injury trends may be more or less favorable (35). In addition, the WINS model can be leveraged for other studies designed to examine etiologies of farm-related injuries, or other health and safety concerns, in farm children and adolescents.

Direct calls and intimations for improved farm-related injury surveillance in the U.S. are widespread (2, 12–16). Relative to prior studies on this topic, which typically relied on aggregated estimates of the at-risk population, WINS was able to track and compare injuries in a defined cohort of children and adolescents who did and did not live on active farms, and where the majority of their medical care was captured. The informatics methods used in this injury surveillance model, which combines data from both private healthcare and publicly available sources, are fairly practical and can be scaled more broadly across other

healthcare systems in rural areas with large populations of farm or ranch families. With additional data, this regional project can serve as an initial step toward developing an integrated national farm-related injury surveillance network, which will help farm safety advocates create and track near-term priorities for prevention.

Data availability statement

The datasets for this study are unavailable for public access because informed consent to share said data (beyond the research team) was not obtained from study participants, but are available from the corresponding author on reasonable request.

Ethics statement

The studies involving human participants were reviewed and approved by Marshfield Clinic Research Institute. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the National Legislation and the Institutional Requirements.

Author contributions

JV was the study PI and led the methodological design and execution, as well as drafted the initial manuscript. RLB led statistical analyses and critically reviewed manuscript draft. RRB led data collection activities and critically reviewed manuscript drafts. KB managed the study, assisted with data collection activities, and critically reviewed manuscript drafts. BW assisted with the methodological design and critically reviewed manuscript drafts. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1031618/full#supplementary-material

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The state of all-terrain vehicle (ATV)-related injury among Israeli children: Data and regulation

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KEYWORDS

all-terrain vehicles (ATVs), children, socio-ecological model (SEM), falls, rollovers, regulation, Israel, Quad bikes

Current situation

In the past, all-terrain vehicles (ATVs) were used in Israel exclusively for agricultural work, such that to purchase an ATV one had to offer proof that one worked in agriculture. This is no longer the case (1). The uses of these vehicles in Israel have expanded to include sports and leisure. According to researchers from the Gertner Institute for Epidemiology and Health Policy Research, approximately 680 ATVs or Quad bikes are sold annually in Israel, of which 12% are used for sports, 32% are used to train beginners, and 56% are used for leisure (1). Moreover, most of the injuries involving ATVs/Quad bikes in Israel occur in the context of leisure and sports activities, and not as part of agricultural work (1).

In what follows, we will inter alia offer data on how the level of ATV-related injury varies as a function of demographic variables, including ethnic background. Demographically, as of 2022, Israel's citizenry is comprised of 9.523 million people, of whom 7.069 million are of Jewish descent, 2.026 million were of Arab indigenous descent, and 498,000 identify as neither (2). In 2020, 3.049 million children (aged 0–17) lived in Israel, of whom 2.207 million were of Jewish descent (72.4%), and 737,000 were of Arab descent (24.2%) (3). An additional 105,000 children (3.4%) were classified as "others" (3) (see Box 1).

The legal and regulatory situation in Israel, as regards children's use of ATVs, is ambiguous. Most notably, because many ATVs are defined as toys under the law (4–6). On the one hand, Israeli laws prohibit adolescents younger than 16 from driving motorized ATVs (7) [articles 188 and 179 (8)]. These laws also require that the prospective driver possesses at least a minimal driving license (in Israel, a tractor license is considered to be the most basic for a motorized vehicle) (9). Moreover, Israeli law proscribes driving motorized ATVs in terrains defined as 'roads' by the Ministry of Transport and Road Safety, with the exception of roads enclosed in agricultural villages such as Kibbutzim (9). On the other hand, there are ambiguities in the laws pertaining to the use of electric ATVs by children and adolescents in Israel. The Standards Institution of Israel does not propose relevant standards for children's vehicles traveling at speeds exceeding 8 kph (kilometers per hour), including ATVs (4). Notwithstanding the noted regulatory ambiguity, the popularity of ATV usage is widespread in Israel (5). The

BOX 1 A statement on the use of ethnic categories in the text

In what follows, we refer to two main ethnic groups which comprise Israeli society (though there are smaller ethnic groups in Israel as well): people of Jewish descent which constitute the ethnic majority and people of indigenous Arab (mostly Muslim) descent, who constitute an ethnic minority. As a shorthand, we will refer to the former as "Jews" and to the latter as "Arabs." This is considered commonplace usage in Israeli society and in some of the scholarly literature cited herein.

number of ATVs in Israel is estimated in the thousands. According to news reports, 4,579 ATVs were sold in the year 2020 in Israel, 800 more than in 2019 (10)—these are dramatically higher figures than the approximate figures cited above, albeit for a slightly earlier period (1).

Three factors underscore the need for research into ATV-related injury in Israel: their popularity, the incidence of injuries, particularly among children, and the dearth of relevant data. According to Siman-Tov et al. [(9), p. 540], "[I]n Israel, crash mechanisms data are absent, as the National Trauma Registry does not record this information". Nevertheless, data from around the world points toward the prevalence of falls, collisions and rollovers (9), as the leading crash mechanisms. Albeit exceeding the scope of the category of children, a retrospective study based on data from the Israeli National Trauma Registry, by Siman-Tov et al. [(9), p. 541] found that, between 2008 and 2016, "Non-Jews (31.5%), males (83.3%) and users 15–30 years old (64.5%) had the highest prevalence of ATV-related injuries," with the category of non-Jews composed primarily of Arab ATV users.

Meanwhile, our data at *Beterem-Safe Kids Israel* (*Beterem*, in what follows), which focuses specifically on pediatric ATV-related injuries between 2012 and 2021, indicates that at least 267 children (defined as individuals aged 0–17) have incurred injuries from riding ATVs. At least in 112 of these cases (or 41%), the main cause of injury from riding ATVs were falls, in line with the extant research. Meanwhile, rollovers occurred in at least 43 of the cases (or 16%). More marginally, collisions while riding ATVs occurred in only 10 of the cases (that is, 3%). Judging by the data, the majority of cases involved motorized ATVs, although coding ambiguities preclude a clear-cut determination on the precise (motorized/electric) nature of the vehicle.

Current activities

Despite problematic regulation, several attempts to address the phenomenon of ATV-related injuries have been proposed in recent years. One policy that came to be implemented, was described in an internal document of the Israeli police, which was leaked to the news media (6). In this document, police officers were instructed to confiscate and destroy electric ATVs (6). In addition, they were required to open criminal investigations against riders failing to present driving licenses, registrations and insurances (6).

The said police document clarifies that electric ATVs are not vehicles under existing Israeli law. Nevertheless, insofar as ATVs are spotted on roads, police officers are instructed to treat them as vehicles (6). In other words, under the terms of the said police instructions, the same laws governing motorized vehicles are to be applied to electric ATVs, and, as noted above, said laws disallow motorized ATVs from traveling on roads. These laws also obligate drivers to carry driving licenses, vehicle registration documents and insurances. But since, as noted above, electric ATVs are not regarded as vehicles under the law, such documentation cannot be presented by definition.

From the perspective of Israeli law, an ATV would have to be defined as a vehicle in order to be licensed, registered and insured. The only such ATVs are motorized. However, the legal definition of motorized ATVs suffers from circular reasoning, as it defines vehicles by stipulation, ignoring most of their technical features. Indeed, the registration of ATVs as motorized ATVs is a precondition for conferring upon them the legal status of vehicles, no matter the technical commonalities an electric ATV might share with motorized ATVs (other than an engine) (6). To qualify as a motorized ATV, a vehicle has to be designed for exclusive use on unpaved roads and satisfy the following cumulative conditions (6):

1. it must possess at least four wheels;
2. the driver's sitting position must be such that the legs are on opposite sides of the seat;
3. it must be steered by handlebars;
4. it must be designed for the transportation of no more than two individuals including the driver;
5. its engine capacity must not exceed 1500 Cubic Centimeters;
6. it must be registered as a motorized ATV;

While electric ATVs satisfy most of these conditions (with the exception of Condition 5, as they do not possess an engine), they are not registered as motorized ATVs. For this reason, they are not regarded as vehicles.

Israel's National Road Safety Authority proposed in 2020 another measure, which may address the above legal ambiguities. It recommended the adoption of an OECD standard – a standard developed by the International Road Traffic Safety Data and Analysis Group (IRTAD). According to the proposed standard, the risk posed by a vehicle should be assessed according to four types: light and slow (Type A), light and fast (Type B), heavy and slow (Type C), and heavy and fast (Type D) (4, 8). Thus, the heaviest and fastest ATVs—those exceeding 25 kph and/or weighing over 35 kilograms (or types B-D)—would become legally equivalent to larger vehicles in the same speed and weight categories (4). However, so far, Israel

has not implemented the proposed standard, though decision-makers may be moving in this direction.

Current challenges

The noted legal and regulatory ambiguities which surround ATVs are not merely descriptive of the situation, but also constitute a challenge for those seeking to improve the state of child safety in Israel. However, there are other challenges. Such challenges operate at the institutional, cultural and individual levels.

For one, toy stores specializing in selling electric ATVs intentionally omit their top (that is, their maximal) speeds. Yet the ATVs sold in these stores may reach the speed of 70 kph. The said stores omit relevant information in order to avoid legal prosecution (4). They do so also in order to satisfy the customs classification of their ATV merchandise as ride-on toys. As it happens, this customs classification places the maximal speed of ride-on toy ATVs at 12.8 kph (4)—significantly below 70 kph, the actual speed of some of the ATVs sold.

In addition, and in line with the sociological characterization already cited from Siman-Tov et al. (9), children's ethnic background is likely to affect the probability of incurring ATV-related injuries. While the MDS form, used to gather the data comprising the MDS database, does not include direct questions on the child's ethnic background, it includes the municipality in which the child resides. Children residing in towns and cities wherein more than 80% of the population are Muslim-Arab, led to the imputation that the injured child's ethnic background was Arab. That is, because Arab majority towns in Israel are virtually homogenous from an ethnic point of view. But such imputation excludes ethnically mixed municipalities which are for the most part Jewish, with sizable Arab minorities. The methodological challenge of ethnically mixed cities also produced an underestimation of both Arab and Jewish children. Despite these limitations, our data indicate that in the years 2012–2021, Arab children incurred at least 70% of the injuries from being hit by ATVs as pedestrians, whereas Jewish children constituted at least 22% of those injured in this manner. At lower levels of injury incidence, Arab children constituted 29% of pediatric injuries from riding ATVs in the years 2012–2021. Broadening our scope to pediatric ATV-related injuries from both riding ATVs and being harmed by them otherwise (e.g., either as pedestrians or by various parts of the ATV while operating it), Arab children amounted to 32% of said injuries during the time-period under investigation. Meanwhile, Arab children constituted merely 24–26% of the overall population of children in the relevant years (correspondingly, Jewish children constituted 74–76% of Israel's population of children in the same years). These data indicate varying levels of Arab children's representation in the context ATV-related injury.

The slightly higher representation of Arab children than their share in the overall population, with reference to injuries resulting from riding ATVs, as well as their notable overrepresentation in being hit by ATVs, align with Beterem's (11) earlier findings regarding the overrepresentation of Arab children across other types of childhood injury. Similarly, the varying levels of representation of Arab children in ATV-related injuries reported herein (ranging from slightly higher than their share in the population to notably higher than their share), resonate with previous data on the overrepresentation of Israeli non-Jews from other age groups in ATV-related injuries. Although the category of "non-Jews" in Siman-Tov et al.'s (9) study, cited above, includes other minorities as well, Arabs constitute Israel's largest non-Jewish minority (~21% of the population).

Outside of the distribution of ethnic background, it is also worth mentioning that of the 267 children injured while riding ATVs, at least 191 (or 71%) were males, while only 75 (or 23%) were females (the rest are missing data). Moreover, approximately half of the ATV-related injuries for the studied time-period occurred among adolescents.

What the above data implies is a multilevel structure of sociological influences upon children's individual risk behaviors, in line with the socio-ecological model (SEM) (12, 13). As Baron-Epel and Ivancovsky [(12), p. 49] explain, the socio-ecological model is

> [. . .] based on the idea that an interaction exists between the individual and the environment, where the individual's behavior is determined to a large extent by the physical and social environments. The behavioral, physical and social environments can be analyzed by the four ecological levels of society, from the individual level through the interpersonal level that includes family, friends and other social networks, through the community level that includes social norms, social institutions, and up to the societal level to include public policy on the national level.

They also point out that "[T]his model may serve as a good framework to understand the differences in injuries between a minority and majority population such as Arabs and Jews in Israel." [(12), p. 49].

The derivative challenge is that preventive policy may be difficult to coordinate when the etiology of injury operates at multiple levels of social organization. That is, because modern society is a highly bureaucratic social setting, Israel being no exception. Moreover, besides the routine challenges of coordination, Israeli society is also plagued with various forms of institutional and budgetary discrimination vis-à-vis its Arab population (12). Indeed, previous cross-country research has established strong associations between, and proposed causal mechanisms relating, socioeconomic inequalities and a series of social and individual ills, including traffic accidents, and lack of

adherence to safety measures as well as a tendency to dismiss other social norms (14).

Future directions

We wish to echo the recommendation of Israel's National Road Safety Authority to adopt the OECD standard for the regulation of electric ATV use, and add a few others. For one, at the structural and regulatory levels, it is obvious that policy-makers must eliminate the gaps and ambiguities reviewed herein. Secondly, other institutions and their nature have to be taken into account. Thus, for instance, the profit motives of ATV dealers should be acknowledged and tackled. Provisions need to be put in place in order to prevent the withholding of adequate safety information from customers and regulators. For instance, fining perpetrators may prove helpful. Finally, in line with Siman-Tov et al. (9), we believe it is crucial to take into account the sociological characteristics of groups suffering from a higher incidence of injuries. These authors singled out the sociological categories of "non-Jewish, male and age group 15–29 years", and emphasized the need to reckon with the "language and culture characteristics which should be considered in planning any public campaign" (p. 544). We wish to apply the same reasoning more neatly to pediatric ATV-related injuries. As we have seen, not only adolescents or males, but also Arab children, suffer from higher incidences of ATV-related injuries. The latter and their parents, require not merely culturally sensitive messaging, but also structural reforms addressing the economic and infrastructural strain on this underprivileged sector of Israeli society. Finally, in line with the foregoing, messages targeting Arab families must bear in mind the material limitations besetting their daily lives.

Author contributions

YG was responsible for the write-up and data analysis. DO contributed to the conception of the study and to collecting literature. EC contributed to data extraction and analysis. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Safeguarding youth from agricultural injury and illness: The Australian experience

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1. Background

As of 31 March 2022, there were 25,890,773 estimated resident population in Australia across the eight states and territories (1). In the 2020–21 Financial year, there was 387 million hectares of agricultural land (50% of Australia's land mass), of which the majority (86%) was used for grazing (2). There were 228,372 people in the Australian agricultural workforce in 2016, 69% were males, the median age was 56 years, and a third (37%) were owner operators (3).

In Australia, fatalities on Australian farms have remained steady over the last decade, with 1,584 between 2001–2020 (4). Children represent approximately 15% of these deaths (5, 6). Issues that have been found to be of importance to farmers about the safety of their children on farms in Australia include: general danger avoidance and safety, machinery, moving vehicles, bike safety, animal handling, personal protective equipment (PPE), supervision, speed, water safety and chemicals (5).

Peachey et al. (2020) explored the 222 deaths of children (<15 years) on Australian farms over a 19-year period (2001–2019) (6). Of the 222 deaths, 51% were less than 5 years of age, 22% were 5–9 years and 27% were 10–14 years (6). The majority (68%) of these deaths were residents of the farms (6). In the final years (2017–2019) of the study there were 13.0 cases per annum, a significant reduction from 1989–1992 where there were 29 deaths per annum (6, 7). Common agents involved in child deaths have not changed much over time, with the exception of quadbike-related deaths of which there were four between 1989–1992 and 32 in the 2001–2019 period, with drowning in dams continuing to be a major cause of death (6, 7). Interestingly, while water safety accounts for 31% of deaths on farms this was not seen as the highest priority by parents (5, 6). Farm dams remain an ongoing challenge for farm safety (8, 9), partly due to changing climatic conditions with dam water level ranging dramatically from year to year. Other common agents, also reflected in the concerns of parents included quadbikes, tractors, utes (farm pick-up), cars, motorcycles and horses (6).

The leading organization responsible for improving safety on farms in Australia is Farmsafe Australia (FSA). FSA is a not-for-profit organization dedicated to improving the wellbeing and productivity of Australian agriculture through enhancing health and safety practices. FSA grew from local action in the 1980's and has operated as Australia's leading agricultural health and safety organization. FSA develops and delivers a range of resources and programs in Australia and has recently (2019) received multi-year funding

from the Australian Government to enhance farm safety (10). Recent activity from FSA has included the production of community service announcements, reports, refreshed guides and brochures, data collection around safety issues, conferences, and attendance at field days (www.farmsafe.org.au).

Toward the end of the 2000's and into the 2010's a number of research activities around child safety reached their culmination, this included work around developing an evidence base for child injury prevention priorities for Australian farms (11), safe play areas (9, 12), water safety (8, 9, 13), and links to the Australian curriculum (14). A recent literature review (15) identified 41 peer reviewed papers exploring child safety on farms, the review noted that there is limited literature on child safety on farms, that factors which contribute to child injuries on farms include; exposure to hazards, risk-taking, lack of supervisions, children working, lack of regulations including understanding of the hierarchy of control, lack of supervision, financial challenges and poor uptake of safe play areas (15). Unfortunately, there is limited information about the relationship between injuries and work for children on farms in Australia, an area requiring further research.

There is no doubt that child safety on farms represents a "wicked problem" (16), that is a problem that requires multifactorial solutions due to its complexity. To address child injury on farms, FSA has used the hierarchy of control approach [i.e., removing the hazard, substituting for a lesser hazard, engineering solutions, management solutions and lastly personal protective equipment (17)] and this is then reflected in the material they produce and the way safety is communicated.

2. Current activities

There has been a wide range of resources developed for child safety on farms in Australia over the years, the following is a summary of those that are still available or known to the Author. Farmsafe Australia has played a significant role in the development of these resources. However, other organizations such as Kidsafe, Royal Life Saving Society – Australia and doctor groups have also been involved. These resources have ranged from practical advice such as the "Child Safety on Farms: A Practical Guide" (18) to pamphlets, brochures, television shows and commercials.

An early example of an integrated child safety program was Giddy Goanna. This program originated in Queensland and went Australia-wide. It included books, activities, television program, a mascot (Giddy Goanna – which was hot to wear) and addressed all farm activities from working with sheep and cattle to chemicals, farm machinery, water safety and feeding pets. The resources as still found in schools and are available to purchase (at Dec-2022) and includes merchandise.

Recently FSA has partnered with "George the Farmer" (https://www.georgethefarmer.com.au) to produce a song with a video about child safety and an educator's guide (19). George the Farmer was developed as a tool for educating children about where their food and fiber come from and is used in schools as an education tool *via* videos and booklets. The educator's guide links to the Australian Curriculum for Year 4 in science, technologies, English, health and physical education (19), however, can also be used with younger children. It provides safety information around jobs and activities on farms and has activities to help embed the learning outcomes.

This work builds on the child safety on farm – a practical guide (18) material and the RIPPER resources (14). The practical guide provides specific advice on how to prevent drowning, injuries due farm motorbike, farm vehicles, horses, tractors and machinery and more general advice around other hazards, it also include a section on "Safe Play Areas" (18). The RIPPER material provides information about farm safety for teachers, links to the curriculum and has a wide range of activity sheets (14). Both of these are still widely used across Australia.

A significant activity of Farmsafe and its partners has been the promotion of safe play areas. This concept originally develop in the USA, was then adopted in Australia with a range of resources to promote the concept to Australian farmers (20). It is especially relevant to farms with young children, as they have been found to wander far from the farm house and end up drowning in dams (8). The program includes information about the benefits of safe play areas', how to make an effective barrier and safe play area, and the role of supervision (20). This work has meant that the number of farms with safe play areas has increased, although only two-thirds of parents reported that it would be secure enough to prevent children from wandering away (12).

Other activities include "Farm Safety Days for Children", these activities normally take children onto farms and have a range of safety talks, experiential learning, chats about farming and practical advice and involve the local hospital/doctors, Farmsafe, Kidsafe, Royal Life Saving, schools, farmers, stock and station agents, machinery dealers and retailers, parents, and other interested parties. Farmsafe also includes strategies within other areas, for example quadbikes where children are expressly mentioned (21).

Kidsafe (https://kidsafe.com.au) and the Royal Life Saving Society – Australia (https://www.royallifesaving.com.au/) have also developed a range of resources to help parents keep their children on farms safe. This includes videos, books, brochures, guides (https://www.kidsafewa.com.au/resources/) and a sign about shutting the gate (https://www.royallifesaving.com.au/stay-safe-active/locations/farm-water-safety). This material is used widely as part of their community outreach. The Kidsafe parent guide is in its third edition and includes information around how to prevent injuries, safe play areas, specific hazards and what to do in an emergency.

Finally, we should not forget legislative approaches. In Australia, there are two significant areas of legislation, workplace

health and safety legislation and child employment legislation. Workplace health and safety legislation takes a risk management approach using the hierarchy of control, however, the child needs to be old enough to be working for this legislation to be relevant. The child employment legislation covers how old, when and what activities children can undertake (22). While these laws are state and territory specific, the general approach is that children should not be working full-time until they are older than 15 years, with some work allowed under this age, however, it should not interfere with school (i.e., should not be during school hours, or be of such a volume that it would impact on learning with some states specifying times when children cannot work), nor place the child in danger with some states specifically banning some types of work (for example dangerous machinery, dangerous substances, working at height, service of alcohol, gambling services, etc.). Often excluded from these provisions is working for family or domestic chores, volunteer work (i.e., unpaid work) or traineeships. This means that work on farms is often excluded from scrutiny under the legislation and thus other strategies to ensure child safety on farms are required (22).

3. Impacts and challenges

It is difficult to tell what impact any given resource has had in preventing child injuries and deaths on farms, as there has been very little evaluation of any specific initiative, this is an area that requires further work. Peachey et al. (6) in their exploration of child deaths found that the average number of deaths on farms had decreased from 17.6 deaths per annum in 2001–2003 to 13.0 in 2017–2019, while this is good news overall, unfortunately the death rate remained unchanged representing a decrease in the number of children living on farms (6). Safe play areas have been widely promoted and its uptake has been varied (12) and it is not clear how long the barriers last, noting that it should also be accompanied by a set of rules to guide the child and parents.

Growing up on a farm provides many life experiences that other children do not get to experience, these life experiences are often encouraged by parents, however, there is a need to ensure that they occur safely and that parents understand what they need to do to ensure the safety of their children.

It appears that exposure to hazards continues to be a challenge, especially for children under the age of 5 years (15). With the number of children who are living on farms decreasing and overall smaller family sizes, there is an ongoing need to ensure that new parents are aware of what can be undertaken to ensure the safety of their children. Child care continues to be a challenge for those living and working on farms, especially those away from population centers (23). With a connected world, noting that this is still a challenge for many rural Australians, there is a need to continue to innovate to ensure that safety information is accessible, engaging and valid for the next generation of parents.

4. Future directions

While the number of deaths on farms has decreased, mainly due to fewer young children living on farms, little is known about non-fatal injuries of children on farms, and there is a lack of evidence about what works to prevent injuries, both areas that need further exploration. As farms adapt to the changes in legislation [note in 2011, Australia started to update its workplace health and safety legislation to be more consistent (24)] and improve their safety performance, it is hoped that this then flows into the child safety area. This needs to be tested around the impact on farming practices and the safety of children on farms.

The next steps in Australia should be around bringing together all the interested parties in child farm safety and working toward a nationwide coordinated effort, which will hopefully develop a child safety on farms strategy, linked to the hierarchy of control approach, as the guiding principle outlined in workplace health and safety legislation in Australia (25). This would expectantly bring new energy and resources to the cause and thus continue to drive down child deaths and reduce the number of injuries on farms while at the same time ensuring that children continue to develop as young farmers. This will require improving the evidence base for what works, ensuring that researchers, practitioners and policymakers work together and that we continue to develop new and adapt current recourses to the task.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of interest

RF is a board member of Farmsafe Australia, Kidsafe, Royal Life Saving Society - Australia, and Auschem Training.

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A feasibility study of Augmented Reality Intervention for Safety Education for farm parents and children

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Agriculture is one of the most dangerous U.S. occupations with high rates of injuries and fatalities, and especially more dangerous for children, having more young worker deaths than any other industry. Thus, safety education is essential in promoting safe and healthy working habits in agriculture. Augmented reality (AR) technology has great potential to enhance the effectiveness of safety education due to its high levels of system-user interactivity and media enjoyment. This study aims to: (1) develop Augmented Reality Intervention for Safety Education (ARISE), an AR 3D simulator that presents farm accident situations with immersive media technology, (2) examine the feasibility of ARISE, and (3) evaluate the potential of ARISE as an effective agricultural safety education program for farm parents and children. To test the feasibility of ARISE, we conducted semi-structured in-depth interviews with ten parent-child dyads at an extension office located in Maryland. Participants were farmers who owned and operated a family farm(s) with their child or children ages 5–13. The interviews included asking participants questions about their perceptions of farm risks, sources of risk education, and protection methods. In the next step, participants used ARISE with researcher guidance. After using the application, participants were asked questions about their experience using ARISE and suggestions for improvement. The interviews were then transcribed and analyzed following the conventional content analysis method. Three main themes emerged—*demand* (e.g., perceived risk and need for education; lack of farm safety education from school), *acceptability* (e.g., attitude toward AR technology; perceived realism; perceived ease of use; perceived usefulness), and *implementation*. These findings help us understand how an immersive experience can play an impactful role in enhancing agricultural safety. The feasibility of ARISE sheds light on the potential of AR technology for an innovative safety education program.

KEYWORDS

augmented reality, AR, agricultural safety, farm safety, children, public health intervention, feasibility, acceptability

Introduction

Agriculture is one of the most dangerous occupations with high rates of incidents and fatalities in the western world (1) and in the United States (2, 3). Agriculture is also more dangerous for children than any other demographic, having more younger worker deaths than any other industry and a much higher proportion of youth worker deaths compared to adult workers (4). Further, agricultural workplaces often double as home as well, which places young, non-working children in dangerous worksites. Thus, safety education is an essential component in promoting safe and healthy agricultural environments, but current safety education for children largely depends on parents' guidance and/or first-hand experience.

Augmented Reality (AR) technology has great potential to enhance the effectiveness of safety education due to its high levels of system-user interactivity and media enjoyment. AR technology allows computer-generated or extracted real-world sensory information (e.g., sound, video, or graphics) to be overlaid on a physical environment directly or indirectly in real-time (5–7). AR prototypes have been applied within agricultural safety and health, and specifically in the application of emergency response safety (8, 9). Further, AR has shown effectiveness in improving safety and health in occupational safety [e.g., (10, 11)] and in safety education for children [e.g., (12)]. Despite evidence of effectiveness, it has seldom been used for children's agricultural safety education. Thus, this study aims to: (1) develop Augmented Reality Intervention for Safety Education (ARISE), (2) examine feasibility of ARISE, and (3) evaluate the potential of ARISE as an effective agricultural safety education program for farm parents and children.

Materials and methods

Augmented reality and safety education

Augmented reality (AR) refers to "a live direct or an indirect view of a physical, real-world environment whose elements are augmented by computer-generated input, such as sounds, graphics, or GPS data" [(13), p. 1351]. Different from virtual reality (VR), which provides users with fully immersed experiences through a purely-synthesized virtual environment, AR brings a virtual object into the real-world setting, which aims to enhance the real-world experience with synthetic information *via* visualizations and audio (14). Augmented reality is more easily accessed by mobile electronic devices (e.g., tablet PCs and smartphones) and its users can control their presence in the real world, which helps enhance both virtual and real-world experiences.

In recent years, AR technology has been applied to a variety of fields such as agriculture [e.g., (15)], healthcare [e.g., (16)], education [e.g., (17)], behavioral science [e.g., (18)], food science [e.g., (19)], safety interventions [e.g., (20)], and journalism [e.g., (21)]. Among them, safety education is one of the fields in which AR has been widely adopted. For example, AR interventions have been developed and applied to driving simulation [e.g., (22–24)]; evacuation research under disasters (25); safety training in the construction (20); and health and safety intervention among elderly people (26, 27), specifically, how AR reduces fall risk in the elderly and navigate memory loss issues.

Past research confirms the potential of AR interventions for effective and practical safety education tools. For instance, Schall et al. (23) developed an AR safe driving education intervention and evaluated its effectiveness in detecting hazardous objects on roadways and directing elderly drivers' attention. Using AR cues in the interactive driving stimulators, they found AR can improve elders' driving safety by increasing hazard detection without affecting their other driving tasks. This study shows AR technology can mitigate the crash risk for elderly drivers. Chandrasekera et al. (26) created an augmented space for older adults that could potentially help solve their difficulty in living independently, primarily due to memory loss and physical impairment. They developed a hybrid space with an AR object location and information system. They found older people used the system with ease and were open to the idea of using such augmented space to enhance their living environment.

AR safety interventions also improve crisis or emergency management ability (25) and safety training in the construction industry (20). Lovreglio and Kinateder (25) conducted a systematic literature review about how AR was used to improve building evacuation when disasters such as fires, earthquakes, and tsunamis occurred. The result showed AR evacuation tools were effective in evacuation training, as the intervention enabled the tracking of user position, orientation, and input. This study showed the use of AR filled some gaps in improving evacuation effectiveness as compared to VR and other methods. Hasanzadeh et al. (20) delved into construction workers' risk behaviors and investigated whether providing passive haptics in the mix-reality setting could help capture workers' risk-taking behaviors, identify at-risk workers, and propose injury-preventative cues. Findings indicated that the immersive environment was suitable for triggering workers' behavioral change; meanwhile, it could help evaluate workers' risk perception and risk-taking behaviors in a risk-free setting.

In addition to the diverse topics and areas, AR safety education interventions have been developed and studied for diverse populations, such as people with reduced vision (28), older adults with physical impairments (26), and construction workers (20). However, children, more specifically farm children, have seldom been target populations of immersive media technology interventions, although they are much familiar with this type of technology; thus, AR technology has

the potential to be an effective intervention for enhancing risk awareness and safety education.

Development of Augmented Reality Intervention for Safety Education (ARISE)

ARISE is an AR 3D simulator that presents farm accident situations with immersive media technology. To create ARISE, we collected and analyzed cases of child-involved agricultural accidents obtained from the *AgInjuryNews* database (https://www.aginjurynews.org). Originally launched in 2015 and later redesigned in 2018, the AgInjuryNews database provides a growing collection of U.S. and Canadian agricultural injury and fatality reports, primarily sourced from news media (29, 30). Using the database, we searched news reports published in 2018 about agricultural injuries involving kids under 18 years old and identified dominant patterns of child-involved farm accidents. An analysis of the cases showed that the most common causes of youth farm injury and fatality include: (1) run over by tractors or trucks and (2) falling off or falling into farm machines. In addition, considering that many farms raise livestock animals, we added one additional risk scenario that involves livestock. Therefore, there are three risky scenarios in ARISE: tractor run-over, falling off a truck, and horse kicks (see Appendix 1 in Supplementary material).

Once we selected children-involved farm injury cases, we developed ARISE using ARKit with Xcode 9. ARKit is Apple's augmented reality framework that can run on any iOS device. ARKit uses VIO (Visual Inertial Odometry) to accurately track the world around the device, which enables a realistic user experience. Xcode is IDE (Integrated Development Environment) for iOS, which provides software development tools to create augmented reality applications using ARKit framework.

TABLE 1 Demographic and farm information of participants.

Participants' names*	Farm type and size	Machines on the farm
LeAnne and Dillion (8-year-old boy)	Split households with two farms: (1) a 14-acres farm with cats, chickens, goats, and lambs, and (2) a 1,000-acres farm with cow-calf operation, feeding out Angus operation, hay operation, and crops growing	Lawnmowers, tractors, skid loaders, telehandlers, and trucks
Rick and Hayden	460-acre farm with grain and chicken	Tractors, big trucks, tractor trailers, some construction equipment
Mary and Bailey (11-year-old girl)	100-acre farm for grain elevator	Tractors, trucks, skid loaders, and conveyer systems
Sherry and Paige (9-year-old girl)	10-acre farm with horses, goats, chickens, dogs, and a garden	Rangers, four wheelers, lawnmowers, tractors, wagons
Carey and Brian (5-year-old boy)	250-acre farm with pigs and grains	Combines, tractors, drop trailers, trucks, and tractor trailers
Lydia and Caleb (9-year-old boy)	Part of a big family farm with chickens, horses, pigs, and grains	Combines, tractors, spreaders, and sprayers
Kate and Colton (10-year-old boy)	A 58-acre farm (two sections) with cows, longhorns, pigs, goats, llamas, alpacas, and chickens	Hay balers, hay wagons, tractors, poultry equipment
Emilia and Waverly (12-year-old girl)	A dairy farm with 140 milk cows	Tractors, tractor trailers, trucks, feeders, mixer wagons, and skid steers
Caroline, Hallie (13-year-old girl), and Mackenzie (12-year-old girl)	A small farm growing vegetables and raise a few animals including pigs and lambs	Tractors and zero turn mowers
Chelsea and Kiley (9-year-old girl)	A hobby farm with horses, steers, goats, chickens, dogs, cats, and pigs	No machinery at the moment of the interview. They had a tractor and a bush hog before

*Nicknames have been used to protect participants' privacy.

In-depth interviews and analysis procedures

To test the feasibility of ARISE, we conducted semi-structured in-depth interviews with ten parent-child dyads on November 9th and 16th, 2019 at an extension office located in Maryland. Eligible participants were farmers who owned and operated a family farm(s) with their children aged 5–13. Table 1 shows participants' nicknames and their demographic and farm information. The interview consisted of three parts. In the first part, we asked participants a series of questions about their perceptions of farm risks, sources of risk education, and protection methods. In the second part, we asked participants to use ARISE following our guidance. After participants used the application, we asked them questions about their experience of using ARISE (e.g., the usability of ARISE and its usefulness for safety education) and suggestions for improving ARISE (see Appendix 2 in Supplementary material for the interview protocol). The interview and testing process lasted approximately one hour. On average, the participants used ARISE for about 10 mins, and pre- and post-intervention interviews took about 20 and 30 mins, respectively. At completion, participants were thanked and offered a $100 gift card for their participation.

The interviews were then transcribed and analyzed following the conventional content analysis method (31). We employed this method because this study aims to describe the status

of agricultural safety education and the feasibility of using ARISE for agriculture safety education. First, three researchers independently open-coded three interview transcripts. In this step, we adopted a general inductive approach (32)—the coding categories were not predefined by the researchers but instead emerged from the data. Reading the transcripts in detail, the three coders paid attention to the text relevant to the research questions. From the general inductive approach, preliminary category labels were identified with a word or short phrases from the interview transcripts. The researchers also marked the examples that illustrated the meaning of the preliminary categories. After coding the three transcripts, the researchers met to discuss the categories and examples they found. The common categories were documented and used as a coding framework for the remaining transcripts. The researchers then coded the remaining interviews and re-coded the original three interviews using the coding framework. After that, the researchers met again to discuss the results. Categories with similar meanings were grouped into superordinate themes, which were used to organize the writing of the results.

Results

Demand, acceptability, and implementation are three general areas of focus addressed by feasibility studies (33). The results section is organized to address the three areas. The interview showed that children mostly learned about farm safety from family members. There was a lack of school education and innovative interventions on farm safety, which led to the demand for farm safety education interventions. ARISE has the potential to fulfill the demand because respondents showed great acceptance of ARISE and intentions to implement ARISE within their families and communities. To protect the participants' privacy, we used nicknames when quoting their comments in the following sections.

Demand of agricultural safety education for children living on a farm

Investigation of demand involves understanding the extent to which a new program is likely to be used (33). It involves understanding recipients' needs or actual use of particular interventions. In the interview, respondents showed high-risk perceptions and agreement on the importance of farm safety education. However, we found that farm safety education for children primarily relied on first-hand experience with family education, second-hand experience from local communities and media content, and 4H clubs. Respondents were disappointed about the lack of school-based agricultural safety education, which indicated the demand for farm safety education interventions.

Perceived risk and need for education

The interview showed that parents understood the risks that could happen to children and the importance of teaching children about farm safety. They mentioned that "there's always a risk" (Kate). They were "even losing sleep at night" because "a worst-case scenario goes through my mind" (Sherry). Respondents emphasized that "as a parent, you have to instill safety in your children" (Kate) and "fill their heads with knowledge" (Caroline). Caroline is very cognizant of the potential dangers of working in agriculture. She admits, "it's dangerous for anybody. I mean, lots of farm accidents are going to happen, so we just have to do our best, train them and just keep telling them over and over again… they have to have a little instruction."

Family education and first-hand experience as primary sources

To combat fearful feelings of what could happen, parents and other close family members, such as grandparents and uncles, took responsibility and became the primary source of children's agricultural safety education. Families reported that they have used education strategies, including having open communication about potential risks, keeping leery of hazards, and setting rules. During the interview, it was evident that parents had had many conversations about risks with their kids. For example, LeAnne directed this comment to her grandson, Dillion, an 8-year-old boy, "we spent a lot of time talking about that stuff, and he knew then to stay away from it, the electric fence." Another parent noted that they "constantly remind them [kids] this is dangerous" (Kate) and "always tell them the right thing, what to stay away from… tell them what can happen" (Carey). Another participant mentioned that family members have kept "leery of all the things going around him," referring to the child (Mary), and kept kids "always under adult supervision" (Kate).

Kate specifically noted that she also constantly reminds her children how their environment can be dangerous. She gave us an example saying, "Just yesterday, we have an RTV, which is like a utility vehicle that we drive around… And my little one there, he likes to [play] like a wild cowboy and hang off the side of it sometimes. And I'm always like, you're going to fall, you're going to get hurt. And like as a parent you're almost like sweating." Lastly, families set rules for children to keep them from risk. For example, children were told "don't run out of the yard, don't play under the trucks, even when they're parked, don't get underneath or around or like sit in a tire" (LeAnne). For another example, as Beth said, "if I'm in a tractor and they get off of the school bus, they know that they need to go in the house."

In addition to getting knowledge from family members, children also learned about agricultural safety through "observations [of] and paying attention [to]" (Hallie, a 13-year-old girl) first-hand experience. During the interview,

children and parents shared first-hand dangerous experiences they had and how they learned from them. The experiences ranged from unpredictable animal movements to grain dust explosions. A first-hand experience could be a close-call or near miss. For example, Emilia reported almost being involved in an incident the day before the interview. She said, "I'm a little more protective over it … A lot of the younger kids that are driving the tractor their parents have grown up on a farm, so they don't think of the silly things that I think of. Like, what if it starts sliding? And their little brain gets really nervous where … they end up in the ditch… I mean, I almost had it happen to me yesterday, so luckily, I could get it stopped, but I just think … if you aren't old enough, you don't have the brains to react as quickly."

Similarly, Rick and Hayden reported a dangerous situation highlighting incidents are possible even for seasoned farmers. The father said, "I had a close call. Almost ran over him (Hayden) one time. I had come up into the yard with the tractor, and he was fooling around on the computer. And she (Rick' wife) said she was going to send him out, but I didn't know. He had come up there, and I didn't even see him. Luckily my wife had come out there with him, and she grabbed him, pulled him out of the way. I wouldn't have run him with the tractor, but the implement behind me probably would've hit him."

Colton described an experience when animals chased him and his friends because they wanted to load the animal up. He realized the dangerousness of the experience and said, "I don't think I'll ever do that again." A first-hand experience can also be incidents where an injury did occur. Lydia described this memory to Caleb, a 9-year-old boy, "you jumped off of something in the shed and hit a piece of equipment and cut your leg. Got stitches." The interviews implied that due to their family farming culture, they learn about risks on a day-to-day basis and through the repetition of daily tasks.

Second-hand experience as supplemental sources

Second-hand experience from local communities and media content provided supplementary resources to enhance children's safety education. The second-hand experience was primarily from local communities and used to educate children on safety practices. Chelsea described how hearing about a lawnmower incident led her to tell her children, "Remember when we heard about the little young kid that got run over with a lawnmower? They got injured. I don't know if you might have been too young, but we talked about that. You have to be really careful." She followed up this incident with another memory saying, "and then a friend of ours got hit with a rock from I think a bush hog or mower." After detailing this incident, she looked to her child and said, "that's why we don't come here when the mower [is] going." These second-hand experiences often were tragic. Lydia made a point to share these stories with her children, "Anytime I hear something, I tell them about it. It wasn't that long ago a girl was killed… on a dairy farm… she might've fallen into a grain tank or something." She continued with the notion that "I want them to be scared." She saw this as an effective method for her children to accept the severity of their environmental dangers. While not experienced directly, undoubtedly, community storytelling was used as an educational technique.

Media content also provided plenty of second-hand experiences to learn from. Videos from social media allowed participants to display the dangerous nature of their life. YouTube was a valid source for the visual representation of risk. Rick explained this tactic when he said, "I've actually shown them some stuff on YouTube." He went into detail when describing how dangerous PTO shafts are and the caution required when being around them. The use of YouTube was also common for Caroline, who actively looked for agricultural safety content on social media. "We watch a lot of tractor videos," Caroline said. These parents found that having their children see these hazards enhanced their sense of danger. The use of media was not confined to YouTube. When speaking of her husband, Beth said, "he's really big into Twitter and that kind of stuff. I'm not really, but he does, and he'll tell me stories." They discussed news, but it "depends on how severe it is, if we would share it with the kids or not. Cause you don't want to have them nervous that their dad's doing the same thing."

Sherry spoke about how the media report she saw was actually happening in her community. "They had a really good documentary a while back about the grain bin safety, and that's been something that a number of our local fire companies have participated in. They've done some outreach, even with kids; I know growing up, a loaded tractor-trailer would sit there overnight or in a day. I remember playing in it, you could get up top and play in it, but you could get injured." Sherry and Paige, a 9-year-old girl, did follow this up with a moment of media and second-hand experience convergence. Sherry started by saying, "oftentimes, I'll show them things I see on Facebook… there's one really good graphic of somebody's foot and you can see the hoof, and they have stitches where the horse stepped on their foot." Paige followed up by saying that her friend broke her foot because of a similar instance. Moments of convergence such as these potentially show how mediated experiences can complement real-life experiences in enhancing agricultural safety. After discussing the second-hand experience with family, they "keep that precaution in mind and learn from mistakes" (Hallie).

Lack of farm safety education from school

"Sad" is how Mary described the lack of agricultural education in her children's school system. When asked about the education provided in local school systems, Mary indicated that the only way that children can learn is from their parents. Mackenzie, a 12-year-old girl, stated, "I don't think in regular school we ever really learned about tractor safety. It's mostly

from our parents." Waverly, a 12-year-old girl, supported this when saying, "it's mostly through my parents or family. Like a few times in kindergarten, we watched like a video." Hayden explained one unique experience where his class went on a field trip to a dairy farm, but he largely felt that his school ignored the topic of farm safety. Lydia even explicitly asked her child about farm safety education at his school. She asked, "have you ever learned anything in school?" Caleb responded simply with "no." The parents defaulted to the notion that schools need to do more. Kate gave her critique stating, "they need to do that [include agricultural curriculum]. There should be something cause there [are] a lot of kids, especially in the area where we live. They all live on farms."

The lack of schooling on agricultural safety was partly made up for by the education provided by organizations such as 4H. 4H clubs provided kids interested in agriculture with an avenue to interact and learn from others within the agriculture community. Caroline described 4H as the only organizational learning as it's "really hard to get agriculture into schools." This lack of institution-based education requires parents and children to actively join specialized organizations if they want to receive more systematic instruction on agricultural safety.

However, the respondents reported a mixed reaction when discussing the educational value of 4H. On the one hand, 4H provided advantages over family-oriented education. Carey, who taught a tractor safety certification class to teens in a 4H club, described how the 4H platform was effective in presenting statistics of agricultural injuries that increased their risk perception. On the other hand, some respondents reported drawbacks of 4H education. Mary admitted the inability of 4H to adequately cover all areas of agricultural safety education. She stated, "they talk about the safety of animals …, little things like that. Not really equipment. They do have a driver's safety class." While the inclusion of the driver's safety class is necessary, Mary downplayed the significance as the class is for "fifteen (years of age) and up" and she described how farm children are already operating equipment from a much younger age. The driver's safety course offered by 4H was seen more as a legal requirement by Mary as children can "drive [equipment] on their own farm." LeAnne admitted similar experiences that although the educational materials provided by 4H were important, implementing farm safety education at 4H was very much secondary to family-based learning.

In summary, parent participants perceived farm safety education as their sole responsibility, and their demand for school-based safety education was rarely fulfilled. This increased farm parents' responsibility to protect their children and other children in their agricultural community.

ARISE acceptability

Acceptability refers to how the intended recipients—both targeted recipients and those involved in implementation—react to the intervention (33). In this study, we aimed to learn how farm kids (i.e., targeted recipients) and their parents (i.e., people involved in implementing ARISE) react to ARISE application. Based on the interviews, we learned about their attitudes toward AR technology and their perceived realism, perceived ease of use, and perceived usefulness of ARISE application.

Attitude toward AR technology

Favorable attitude: Unique, fun, and attractive

Respondents generally showed a favorable attitude toward using AR technology for agriculture safety education. Respondents endorsed the use of AR technology because it is more fun and attractive than other formats of education materials. They thought it was "pretty cool" to see the virtual farm on the table (Mary); the handling was "very unique" compared to other non-AR applications (Sherry); it was "fun" to use ARISE for safety education (Kate). As Rick said, "I think that could probably be seen by a lot more people, because people do like to. If that thing was on, say, Facebook, and it had some link about, watch this for farm safety, people would click on it, vs. if they saw some doofus standing up there, trying to do some demonstration."

The attractiveness advantage of AR technology is essential for education targeting kids. Younger kids "have such a short attention span at this age" (Carey), and "farm safety isn't a super exciting topic (for them). If kids had to pick out, what do you want to learn today, I doubt farm safety would be at the top of their list" (Sherry). But because "kids are sucked into electronics" (Mary), a safety education app using AR technology "would probably capture a younger audience... capture attention a lot more than a link to click on a real-life video" (Carey). Lydia also felt that the AR application could "grab the attention more" compared to an adult just telling them how to be safe. Sherry and her daughter, Paige, described an imagined scenario showing how kids would be excited about using AR technology for safety education:

> Sherry said, "If the kids go to a 4-H program…I could see them being excited coming home and saying I got to use an iPad. So instead of I say, 'Hey, what'd you do today at school?' And it's-"
>
> Paige responded, "I wrote a whole essay."
>
> Sherry agreed and said, "Yeah, I wrote a paragraph about farm safety as opposed to-"
>
> Paige said, "I learned about farm safety, using an iPad!"

A second thought: Real-world demonstration and anti-electronics

While hesitant that AR interventions would work for their generation, the adults see the potential for their children. Caroline voiced this by saying, "as a parent, I think I would

buy this app." However, respondents showed a few concerns about using AR technology, although they also admitted that it is the way of learning for their kids' generation. Rick feared that some audiences like him would prefer a non-immersive mode of communication, "I'm kind of a real-world type person. I actually like real demonstrations, more hands-on type stuff." But when being asked if he thought a video recording of a real-world demonstration is better, he said, "I think so. That's just my opinion, but I also grew up learning like that. This generation, maybe not so. They learn a lot from video games and stuff on iPads." Similarly, Mary had concerns about kids using electronics too much. "I'm anti-electronics," she said, "So I really don't think my kids need to be on app any more than they have to be." With a second thought, she also said, "But that's technology. That's the world today. You know, I'm just old school."

Perceived realism

For ARISE to be successful, the farm and the accident scenarios need to be perceived as parallel to real-world farm and risk scenarios. Sherry found that the ARISE farm was realistic. She said, "when you think of a farm, that's probably something that comes to mind." Paige echoed that the AR experience "looks really real." Kate also thought the virtual farm was "neat" because "standing there, you're looking around, you seeing this farm, which a lot of children that do live on farms can relate to everything going on."

The risk scenarios presented in ARISE were also regarded as realistic and very much present on many farms. Kate described them as "real life scenarios." Lydia stated that they were "100%" realistic about what was on the farm. Sherry provided a more descriptive statement, "I think having a tractor or the animal and the vehicle are very accurate portrayals of what type of activity would be going on."

Perceived ease of use

The respondents generally agreed that ARISE was easy to use. They described it as "user friendly" (LeAnne) and "easy to maneuver through, and is interactive to keep their attention" (Hallie). LeAnne said, "I think it's easy enough to hold and walk around…Look here. Tap there. Watch." They also found great use of the ability to zoom in and enjoyed "explor[ing]" (Paige) the AR farm from many different angles and perspectives. As Bailey, an 11-year-old girl, said, what she liked about ARISE most was "how you can move around and see how [it look] like in zoom in, instead of just sitting."

Perceived usefulness

The respondents thought ARISE could be useful for safety education because children could easily understand the risk scenarios presented in ARISE and connect what they watched during ARISE usage to their own experiences. Dillion, an 8-year-old boy, explained that he prepared to look for the wrongdoings when he started to use the application, "when I got it, when I saw all the parts of it, I knew there was going to be something wrong. I knew if it was going to be one, two, or three, but I knew at least one thing was going to be wrong." Kate also stated that her 10-year-old son, Colton, "knew right away before even start[ing] your scenarios." After using the application, the kids interviewed could describe what went wrong in the risk scenarios. Mackenzie said, "I think it's descriptive enough to get their attention and clear enough to get the points through."

Respondents stated that younger kids and kids from the non-farm area would be the ideal target audience for the application. They thought that ARISE would be useful, "especially for elementary age" (Mackenzie) or "pre-K, kindergarten, first grade, second grade" (Lydia). This met the intended audience that ARISE was designed for.

Surprisingly, some respondents felt that ARISE was more beneficial for "the non-farm people rather than the farm community kids" (Mary) because "they [farm community kids] have started early and they understand it's the outside world that is clueless about anything." LeAnne described it as a unique sense of safety awareness by saying, "Because it's so repetitive and it becomes second nature to him. … he pays more attention to it because he's seen it forever … his awareness of what's going on, even if he's not telling you, but deep in here somewhere he notices and remembers that stuff." Hallie outlined, "we learned about some things like… how to stay safe. Even for the kids that aren't as active (in farming), they learned about it when they go into that situation. Just observations and paying attention." Emilia supported the idea that growing up surrounded by the risks of agricultural work serves as a necessary preparation. She does not fear for her own family but senses risks with visitors. She said, "for my children, no [perceptions of risk], because we are very pro-farm safety. Visitors, we tend to kind of keep them a little bit. We try to give them a run-through of like, if you see this coming, move away from the lane, that kind of stuff, it's more outside than our children we're worried about." She thought those new to a farm or visiting a farm could use ARISE to start the conversation on safety. In Carey's words, ARISE would best be used to "spread awareness" to those with little to no knowledge of agricultural life.

ARISE implementation

Implementation is an essential aspect of feasibility and is defined as the extent to which a program can be successfully

delivered to intended participants to achieve its goal (33). Inferences of implementation are made through two subthemes: the likelihood of implementing ARISE in schools and 4H clubs and the advantages of implementing ARISE compared to other educational materials.

Implementing ARISE into classrooms is feasible because the schools are fully equipped with technology and the kids are used to learning through technology. LeAnne mentioned that in the county where the interview was undertaken, "5th grade and up all have a Chromebook that they can take home with them. 3rd and 4th grades have a Chromebook assigned to them that stays at school. And all the kids, from kindergarten up, go through the computer education program." Some respondents felt that implementation in schools that are situated in agricultural communities would benefit greatly. Kate displayed this when she said, "it could be a great program to go into the school. Especially in this area because there's a lot of farmers that have children or grandchildren, there's a lot around here."

In addition to implementing ARISE in schools, the respondents also mentioned the potential to implement ARISE in 4H programs. Lydia felt that 4H would be the best place as children in this setting would all have a practical use for it as ARISE. She stated, "my thought would be 4H. I mean, there's a lot of the children, especially with the animals, a lot of them in our area are in 4H." Respondents involved in organizing 4H events also talked about the potential to implement ARISE at 4H fairs. LeAnne said, "at our fair, our 4H club does an interactive learning tent. That's full of ag education, ag literacy kind of stuff. And we've talked about having a farm safety piece, but we've never been about to figure out a way to put it in the tent..." She also felt that children were the ideal target audience when she stated that "to me, it's obviously this type of program needs to be tailored toward children. Kids are around this sort of thing (AR technology)." She believes it would appeal to many children at 4H who come from an agricultural background.

Respondents also mentioned that using ARISE had advantages over other education materials. Compared to real-world learning, LeAnne stated that ARISE has implementation advantages, "especially in a situation where you can't take the farm into the classroom to teach them. So, it's definitely a cool thing. And all the schools have technology." She also stated that with ARISE, "they (children) can see all around and do all kinds of stuff, and the movement is really helpful for a kid." Carey talked about its portability, "You haul this stuff everywhere; with this, you just take the iPad in, and they can do it right there in the classroom, or afterschool, or daycares. I really like the portability of it, and the fact that you can update it and change it." Similarly, when talking about other education materials about farm safety, LeAnne said, "I've looked at a bunch of them, and we've done some small stuff with the 4H club. The problem is, it's either too big of a setup. Where this is great because it's a tablet, or even if, put it on a phone app, where it's smaller technology, all the farm safety stuff you see is big. They want you to have big equipment so you could see it, which is great, but not practical."

Discussion

This study examines the feasibility of ARISE, an AR 3D simulator that presents farm accident situations (see Appendix 1 in Supplementary material), as an effective solution for farm children's agricultural safety education. ARISE presents three common causes of farm injuries and fatalities (i.e., a child at risk of getting run over by a combine/tractor, falling off a truck, and being kicked by a horse) on a virtual farm projected on a table. The risk scenarios in ARISE were chosen based on an analysis of agricultural injury news obtained from AginjuryNews.org database. Before and after using ARISE, ten dyads of a farm parent and their child share their daily lives on a farm and immersive experience with ARISE. Three themes—demand, acceptability, and implementation—emerged from the interviews, showing ARISE's feasibility and potential as an impactful agricultural safety intervention.

First, there was a high level of risk perception about farm safety issues and considerable demand for innovative agricultural safety education interventions for farm children. This demand was not fulfilled by schools or relevant institutions, which made farm parents or grandparents solely take responsibility for their children's safety education and training. Specifically, it was commonly reported that agricultural safety education mainly occurs through family norms and culture. The interview revealed farm parents were fully aware of the risks that could happen to children in an agricultural environment, and they taught their children how to handle risky situations. The farm parents agreed on the need and importance of farm safety education outside of the family. In addition, the family members largely depended on their first-hand experience and second-hand experience from local communities and media reports, not from institution-based agricultural safety education. The respondents expressed their disappointment about agricultural education being ignored in public school curricula, although the schools are located in agricultural communities. These demands imply that ARISE would be well accepted by the target populations, farm parents and children, if it provides supplemental resources for family-based and first-hand experience-based farm safety education.

Second, the respondents found ARISE to be very realistic, useful, and easy to use, and showed a favorable attitude toward ARISE. All these evaluations indicate a high level of the acceptability of ARISE, a key component of the feasibility of an intervention. Participants found ARISE to be very realistic—both immersive media content (i.e., a virtual farm and farmers/their children's appearances and actions) and selected incident scenarios. An encouraging result was farm children's ability to relate what they watched from ARISE

with their own experiences. They recognized risky behaviors shown in ARISE and connected them to their daily lives on a farm.

Respondents also appreciated the user-friendly nature of the tool and endorsed ARISE as well-designed to maximize natural user-system interactions. Farm parents and their children showed a favorable attitude toward using AR technology for agriculture safety education, describing ARISE as fun to use and more attractive than other formats of farm education materials. This entertainment-like design was developed for young kids who usually have a short attention time. The respondents also highlighted that ARISE would be useful and practical for non-farm children as well, because they have very limited experience and knowledge about the danger of agricultural lives. According to the technology acceptance model (TAM), perceived ease of use, perceived usefulness, and attitude toward usage are key components that predict the acceptance of a new system (34), and users' level of acceptance is a crucial component of the feasibility of an intervention.

Finally, the in-depth interviews revealed a great potential of ARISE that can be successfully delivered to intended users in schools and 4H clubs to supplement the lack of institution-based agricultural safety education. This indicates the high likelihood of ARISE implementation, an essential aspect of feasibility, compared to other educational materials. According to the interviewees, implementing ARISE into classrooms and 4H programs is not only feasible but also desirable, because laptops and tablet PCs have been widely adopted in the public school systems. In addition, throughout the COVID-19 pandemic, children have been familiarized with different learning technologies and platforms.

The portability of ARISE was also indicated as a great advantage. 4H programs and community events were frequently recommended for an educational setting. For example, 4H fairs provide several interactive agricultural learning opportunities but seldom present effective agricultural safety programs, because it usually involves sizable equipment that is hard to put in an event tent. Given that ARISE is a mobile application operated *via* an iPad or a smartphone, use at these events seems feasible.

The interviews also raised some concerns. Some farm parents expressed apprehensions about using immersive media technology because they believed their children spent too much time with media technology, commonly referred to as screen time. They preferred to limit their children's media time, even if the purpose of the media use is educational. At the same time, however, they appreciated the purpose of using AR technology in this project and acknowledged it's somewhat inevitable for their children to use new media more in their generation. When we apply AR technology to children's education, we should consider how we could reduce parents' concerns about using immersive media technology.

It is also noteworthy that some parents regard their own farm environment as more dangerous for visitors than their children, thus, felt that ARISE was more beneficial for "the non-farm people rather than the farm community kids." They showed confidence in their children's farm safety knowledge and practice because their children grew up on farms surrounded by the risks of agricultural work and they taught necessary preparation for handling those risks. Therefore, they argued that ARISE would be effective for those who are new to a farm or visiting a farm, and provide a good starting point for farm safety conversation. However, they believed ARISE would have a limited impact on their farm children. It might be true, but it might be a result of optimistic bias. It is evident that farm children are exposed to more agricultural hazards than non-farm children. Therefore, future research needs to examine if there would be different effects of ARISE between farm and non-farm children.

Although this study primarily used in-depth interviews and its' goal was not a generalization of the findings, it is evident that ten dyads of farm parent and child cannot represent the target populations of ARISE. To bolster and generalize our findings, future research needs to recruit more participants from the target populations and test the feasibility of ARISE with different research methods, such as a longitudinal panel survey or an experiment in a laboratory setting. Beyond ARISE, future study needs to expand the scope of AR applications to resolve other medical and safety concerns targeting a broader research population.

Conclusion

This study sheds light on the potential of the AR technology for an innovative safety education program. ARISE can contribute to the prevention of agriculture-related injuries and fatalities by providing farm parents and children with a user-friendly platform and vivid second-hand experience of incidents that frequently occur on farms. This finding is more meaningful for agricultural safety education because there has been very limited AR intervention research targeting farm children.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Review Board (IRB),

Division of Research, University of Maryland, College Park. Written informed consent to participate in this study was provided by the participants' legal guardian/ next of kin.

Author contributions

KN initiated this project, led the research and development process about the Augmented Reality Intervention for Saftey Education (ARISE), and led the writing of this research manuscript. JL and JC assisted with all research procedures, especially intervention design and data collection, wrote this manuscript together, and especially the research methods and result parts. JZ wrote the literature view part of this manuscript. BW secured the grant with KN, as developing initial ideas and design of this intervention and wrote this manuscript together. All authors contributed to the article and approved the submitted version.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.903933/full#supplementary-material

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Children in relation to agricultural health and safety in Sweden: A perspective

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1. Background

Rights of children have been an important issue in Sweden for many years. The Ombudsman for Children is a government agency tasked with promoting and advancing rights and interests of children in Sweden on the basis of the UN Convention on the Rights of the Child (1). In 1979, Sweden was the first country in the world that made it illegal to hit children, both at home and in school (2). Sweden is also well-known for its efforts to protect children in traffic, with measures such as the rear-facing car seat (3).

Sweden is a country with <60,000 farms, dominated by family operated farms. Their children grow up in an environment that includes not only a significant experience of living close to nature, but also being close to a workplace that might be both risky and unhealthy. In the old days, the farms consisted of many people who were always available to share the care of children. However, nowadays, often one parent works away from home and small children go to daycare or stay with one parent on the farm. There are no official statistics on child injuries on farms, but there is reporting by the media on time to time serious injuries and fatalities among children as well as adolescents by farm tractors and machinery, ATVs, horses, and other large animals (4).

Children on farms and in rural areas have been an important component of different health and safety programs, but research in this area has been limited. Inspiration for Swedish initiatives and actions often came from US organizations such as the National Children's Center for Rural and Agricultural Health and Safety in Marshfield, WI, Farm Safety 4 Just Kids, and the Progressive Agriculture Safety Days, as well as participation in the Childhood Agricultural Safety Network. In 1996, Swedish activities took on this issue of sharing challenges and possible solutions regarding children on farms during the US–Nordic Conference on Rural Childhood Injury Prevention in Stockholm (5).

2. Current situation and activities

There are no current national programs or dedicated organizations focused on childhood agricultural safety in Sweden. Despite this fact, there have been relevant activities, both among farming organizations as well as among researchers. The most relevant activities are presented briefly:

2.1. Children and health and safety campaigns

When there was an occupational health service (OHS) for farmers in Sweden (Lantbrukshälsan) they held a "Year of Rural Child Safety" in 1996, which included a variety of activities. After the OHS was discontinued, the organization of farmers (The Federation of Swedish Farmers—LRF) continued by distributing folders about child safety on farms and other outreach activities. However, when there was a major national intervention program "Safe Farmers Common Sense" during 2009–2013, funded by the EU Rural Development program, the organizers learned that the best way to gain the attention of farmers was to start with the safety related to children. They produced a lot of educational materials and public messages, as well as books, games, and reflective jackets for children (6, 7).

2.2. Guidelines for children on farms

Inspired by the North American Guidelines for Children's Agricultural Tasks (NAGCAT) by Lee and Marlenga (8) a Swedish version was developed with a focus on children on animal farms (horses, pigs, and dairy cows) after a survey of the most common tasks performed by children on farms. The publication supplemented with checklists, and guidelines for first aid and other aspects were used by organizations of farmers and within agricultural schools (9).

A task not included in the Swedish guidelines is the use of farm tractors by children and a study by Pinzke et al. (10) regarding incidents on public roads concluded that the youngest tractor drivers aged 12–16 years were more often involved in road traffic incidents during school holidays and during harvest time. The over-representation of young children in tractor incidents suggests that it is questionable whether they should be allowed to operate farm vehicles without a driving license.

2.3. The farm parent's attitudes and perspectives on risk and exposure for their children

Research regarding the farm *parent attitudes to risk and injury to children* was done (11) and it was concluded that most parents know the risks on their farm, but are sometimes careless when working under stress or exhaustion. Some parents wanted more information and some wanted compulsory preventative or safety measures by manufacturers, e.g. a safety belt as standard on the extra seat in tractors. Children's friends were described as one of the greatest risks for injury due to peer pressure. Some parents mentioned that people who grow up on farms are sometimes "blind" to the dangers. Other parents seemed to overlook the risks and had their children carry out tasks for which they were not mentally or physically equipped. Some of the tasks the children reportedly carried out on farms conflicted with Swedish legislation.

Another study (4) had the focus on *parents' risk acceptance and attitudes toward the use of ATVs by children living in rural areas*. Major findings were that parents were aware of the risks and had a strong commitment to children's safety, but risk acceptance was a common issue, due to risk normalization. Parents did not see themselves as role models for children regarding the use of ATVs. To increase the safety of ATV use, recommendations to organizations and authorities were presented, such as an age limit for drivers of all adult-size ATVs and safety labeling of ATVs, with information clarifying the rules for specific vehicles.

It is also important to pay attention to *mental health and wellbeing among children living on farms*. In a recent study on rural crime and animal rights activism in Sweden by Ceccato et al. (12), it was concluded that also farm children are affected (worries, fear, and sleeping problems) by the increasing rural crime and by threats from animal rights activists toward animal farmers.

3. Current challenges

Living on a Swedish farm is definitely linked to a risky environment for children. A number of actions are needed in order to improve conditions. Farm parents need support and knowledge to safely raise their children. Small children need constant care and might need organized day care, which may not be available in rural areas. Innovative examples of farm families collaborating on childcare services might be a viable solution. In order to for farm parents to be more aware of risks and receive financial and educational resources, the general public should get involved. A promising, new national 5-year program will be launched in 2023 which intends to include the safety of children. A harder challenge is the pending closure of health and safety research within the Swedish University of Agricultural Sciences. In order to develop new knowledge and offer support to agricultural organizations there is a need for research that develops and tests childhood agricultural safety strategies, now and in the future.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Is presence of children or youth a farm workplace injury risk factor on Irish farms?

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1. Introduction

This paper describes identifying a farm workplace injury risk factor associated with the presence of children/youth on Irish farms. Under Irish safety, health and welfare at work legislation a person in the age category of 0–18 years old or still at school are considered a child or young person. However, as the UN defines youth as persons between the ages of 15 and 24 years, this definition related to youth age is used in this paper (1). The presence of children/youth has been overlooked in past studies seeking to identify farm workplace injury risk factors in agriculture. A risk factor has been described as a factor related to the probability of an injury, which allows a population to be subdivided into risk category groups based on the presence or absence of the identified risk factor (2). Gaining information to allow risk factor(s) identification is a prerequisite to developing effective and tailored prevention strategies (2).

To identify a risk factor, securing data related to farm workplace injury occurrence and associated population factors is necessary. A means of gaining data on farm workplace injuries in Ireland has been by use of the National Farm Survey (NFS) operated by Teagasc—the Irish Agriculture and Food Development Authority. The NFS is part of the European Union (EU) Farm Accounts Data Network (FADN), which collects physical, technical and financial data on a nationally representative sample of farms throughout Europe. In addition to core FADN data, the NFS collects data pertaining to sustainability, including social aspects such as health and safety. As such, the NFS has previously been used to gain estimates of farm workplace injury levels through an additional survey mechanism (3). Farm workplace injury survey data gained has been successfully analyzed in association with core NFS data, which provides a considerable range of socio-economic variables, to explore farm workplace injury risks.

Previous research indicates that both behavioral and farm infrastructural factors are likely to be associated with farm workplace injury levels (3, 4). In particular, issues such as working long hours, rushing and tiredness along with under investment in safety related infrastructure and mechanization are likely to be associated with farm workplace injury occurrence. In addition, there is some evidence that indirectly highlights the

presence of children/youth in particular in summer, as the busiest time on farms, when increased workload might be a factor associated with farm workplace injury occurrence (5). In Ireland, an average dairy farm enterprise is recognized as being relatively more profitable (6) and labor intensive (7) than other enterprises, while farm operators work long hours under multiple stressors (8). A previous study based on NFS data indicated that among enterprises dairy farms had the highest level of farm workplace injuries (9). Dairying attracts a younger and farm development-oriented farming population (10) and accordingly, farm families with a dairying enterprise are more likely to have children/youth in the household. While previous NFS based research in the 1990's in Ireland (11) pointed to the possibility of "having children/youth" as a farm workplace injury risk factor, the "presence of children/youth" has been overlooked in almost all previous studies. In contrast, work-related and economic risk factors including gender, age, family size and farm enterprise have been considered in farm workplace identification (12, 13). Therefore, to the best of our knowledge, to date, "presence of children/youth" in all farm enterprises and on dairy farms in particular, as a potential farm workplace injury risk factor has not been well studied.

Accordingly, this study aims to examine the following two main hypotheses:

H1: having children/youth aged under 24 years (H1a) in general, and aged <5 (H1b), 5–15 (H1c), 16–19 (H1d), 20–24 (H1e) in particular within this age range represent a farm workplace injury on Irish farms.

H2: having households with/without member(s) aged 1–24 (H2a) in general, and <5 (H2b), 5–15 (H2c), 16–19 (H2d), 20–24 (H2e) in particular is associated with a higher farm workplace injury occurrence on dairy farms.

2. Methods

2.1. Data collection and measures

Data relating to farm workplace injury was collected through the NFS in 2017. Teagasc, as a statutory body is permitted to conduct such a survey without ethics approval. However, the survey complies with "conditions for consent" under the EU General Data Protection (14).

For comparative purposes, the survey was designed to match those previously conducted through the NFS related to farm workplace injuries (3). A farm workplace injury occurrence was defined as "a farm work related event (including a farm work related road traffic injury) which led to physical harm causing bodily injury" in the previous 5-year period. In total, NFS recorders completed 893 injuries survey questionnaires through face-to-face interviews with individual Farm Operators with main responsibility for the operation of the farm. In this study, to examine the study hypotheses, data related to age profile of farm household members (ordinal scale) and farm enterprise (nominal scale) was combined with farm workplace injury occurrence (binary variable) for correlation analysis. Data for all farms (100%) that participated in the NFS in 2017 is included in this survey.

2.2. Data analysis

Descriptive analysis using frequencies and cross-tabulation analysis were applied to test the study hypotheses. To this end, examining H1a, the correlations between the presence of children/youth (aged 1–24) (Table 1) in farm households associated with occurrence of a farm workplace injury were estimated using cross-tabulation analysis. Equally, Chi-square analysis was then applied to demonstrate the association between having children/youth (aged 1–24) (H1a), children aged <5 (H1b), 5–15 (H1c), 16–19 (H1d), 21–24(H1e) and FWI occurrence reported in the past 5 years (binary dependent variable (yes /no). The same approach was applied for examining H2a and H2b. To estimate the predictive power of dependent variables on the injury occurrence, the crude odds ratio was estimated (15). The data set was analyzed using the statistical package SPSS version 21 for windows.

3. Results

Almost forty percent (39.6%) of family farms indicated having *children/youth (aged 1–24)* in their family households. However, considerable variation existed in the level of children/youth in farm households with dairy farms having a much *higher proportion of having children/youth* compared to other enterprises (16). The two age cohorts including 5–15 (24.5%) and 20–24 (20.7%) formed the main proportion of the children/youth population on dairy family farms.

A "farm workplace injury occurrence" during the previous 5 years was reported by 113 family farms (12.6%) (Table 1), where nearly half indicated occurrence on dairy farms ($n = 54$, 46.9%). The study data identifies dairy farms as the most dangerous farm enterprise regarding farm workplace injury occurrence and it also has the highest proportion of children/youth (47.9%) where 24.6% of farms had children aged 5–15 in their households. Chi-square analysis showed that dairy farmers reported farm workplace injury occurrence as nearly twice the level of other enterprises (Chi-square = 10.84, $P = 0.05$) (Table 1). Regarding the association between having children/youth and farm workplace injury occurrence, there was no significant difference between farm families who had children/youth aged 5<, 16–19, and 20–24 (Table 1). Therefore, H1b, H1c, and H1e are rejected. Interestingly, we found that family farms with children/youth aged 1–24 (39.6%) in their household reported twice as many "farm workplace injury occurrences" compared to families without youth/children (Chi-square = 11.305, $P = 0.001$). as such, H1a is approved. Furthermore, confirming H1b,

TABLE 1 Farm workplace injury occurrence associations with farming enterprise and presence/absence of children/youth by age range in farm households.

Variables (nominal)	Farm injury occurrence ($N = 893$)				Statistical analysis		
	Yes (113, 12.6%)		No (780, 87.4%)				
Farm enterprise (*n*, %)	*n*	%	*n*	%	Crude odds of injury	Test	*P*-value
Dairy farming (313, 35.1%)	54	16.9	259	83.1	0.21	***10.84***	***0.05***
Cattle other (217, 24.3%)	24	11.1	193	88.9	0.12		
Cattle rearing (151, 16.9%)	10	6.6	141	93.4	0.07		
Sheep farming (126, 14.1%)	16	12.7	110	87.3	0.05		
Crop production (72, 8.1%)*	<10	11.1		89.9	0.13		
Others (14, 1.6%)*	<10	14.3		85.7	0.08		
Having children (aged <5)						0.45	0.5
Yes (51, 5.7%)*	<10	15.7		84.3	0.19		
No (842, 94.3%)	105	12.5	737	87.5	0.14		
Having children (aged 5–15)							
Yes (162, 18.1%)	34	21.0	128	79.0	0.43	***12.435***	***0.001***
No (731, 81.9%)	79	10.8	652	89.2	0.12		
Having children/youth (aged 16–19)						0.237	0.60
Yes (143, 16%)	20	14	123	86	0.16		
No (750, 84%)	93	12.4	657	87.6	0.14		
Having children/youth (aged 20–24)							
Yes (132, 14.8%)	22	16.7	110	83.3	0.2	2.25	0.11
No (761, 85.2%)	91	12	670	88	0.14		
Having children/youth (aged 1–24)							
Yes (353, 39.6%)	61	17.3	292	82.7	0.21	***11.305***	***0.001***
No (540, 60.4%)	52	9.6	488	90.4	0.10		

*Observations less than 10 cannot be displayed due to data confidentiality.

the study data shows that "farm workplace injury occurrence" was four times higher for family farms that had children aged 5–15 in their household compared to other family farms (Chi-square = 12.435, $P = 0.001$). Thus, having children/youth, in general, and children aged 5–15 in particular on a family farm is a major risk factor associated with farm workplace injury occurrence. Thus, the study data indicate that having children/youth and having children in the 5–15 age category, in particular should be considered as an important farm workplace injury risk factor, particularly on dairy farms.

4. Discussion/Conclusions

The study findings indicate that two elements of H1 be accepted, namely, the presence of having children/youth (1–24 years old) (H1a) in the farm household and 5–15 year olds (H1c), in particular, is associated a farm workplace injury risk. This novel finding has not been reported previously, to our knowledge. The possible reason why this risk may happen on farms with children/youth could be due to the presence of younger parents (10) who are involved in farm development and farming that is more intensive or off-farm employment. Thus, the risk may be based on the parental stage in life and farm development activities and/or workload. International studies have indicated that increased farm work time increases farm workplace injury rate (17–20) and also in Irish studies (21, 22). In particular, one previous Irish study using NFS data has indicated generally that farm scale, workload, and under investment, influence farm operator farm workplace injury rate (3). This study (3) identified farms where both farm operator and spouse engaged in off-farm employment as a risk factor for farm operator injury risk. A further possible explanation is that childcare, particularly in the 5–15-age category, may require time, which accordingly causes increased work time demands on adult family members. A previous Irish study has indicated that

farmers believe that increased "work time" demand is a major contributory factor for farm injury occurrence (4).

The study data indicates that both elements of H2 should be accepted. Namely, the presence of children/youth in farm households (H2a) and 5–15 year olds (H2c), on dairy farms in particular, is associated a farm workplace injury risk. This is unsurprising as this enterprise is associated with high workload, long working hours and associated stressors and having children could cause higher non-task based work hours spent by parents, which thus increases the risk of FWIs.

Identification of a risk factor indicates that a particular segment of a population has a heightened risk. Accordingly, study of factors leading to the heightened risk is potentially valuable to identify reasons for the increased risk and to identify control measures. The study of farm workplace injury associated with children/youth in farm households has received limited examination in the scientific literature. Given this knowledge gap and the novelty of the findings of this study, further research is warranted on the association between farm workplace injury risk factors and the presence of children/youth in farm families. One way to conduct such research could be a further examination of NFS core data to investigate farm and socio-economic variables related to this issue. A further approach could be to conduct qualitative research using such approaches as interviews, focus groups or case studies among a sample of adult farm family members with children/youth who are in the identified high risk sub population. This approach would gain a nuanced account of the safety and health challenges associated with both working and child-rearing in tandem on Irish farms. Overall this paper in identifying a risk factor indicates new approaches for both research and outreach to reduce the level of farm workplace injuries on farms where children/youth are present.

Author contributions

JM identified the paper concept, sourced the study data from NFS, and prepared the initial manuscript draft. MM conducted the statistical analysis of data in the paper and contributed to writing the manuscript draft. DM and ED reviewed the draft manuscript and provided material for inclusion in the paper. All author read the penultimate version of the paper and provided edits and are in agreement with its content.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Parent perspectives on the benefits and risks of child-livestock interactions

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Growing up on a farm or ranch often involves interactions with livestock that present both potential risks and benefits to children. While these "child-livestock interactions" contribute to the burden of agriculturally related injuries to youth in the United States, they may also result in improved immunological health and other benefits. Agricultural upbringings are also widely perceived to improve physical, cognitive, and skill development of children, contributing to a combination of potential benefits and risks known as the "farm kid paradox." Although previous studies show the health impacts of child-livestock interactions, less is known about the ways in which farm and ranch parents perceive the benefits and risks of these interactions, and how and why they choose to raise children around livestock. Our research addresses this gap by analyzing data from semi-structured interviews with 30 parents of children between the ages of 10–18 who produce beef cattle in Kansas. This research is part of a larger anthropological study of the benefits and risks of child-livestock interactions involving parents on beef and dairy operations in multiple states, along with agricultural safety and health professionals. The results offer insights into the experiences, practices, and perspectives of parents, outlining agricultural ways of life in which safety and relations to risk are shaped by patterns of production, family dynamics, values and habits, and other social and cultural dimensions. These insights deepen our understanding of parents' perceptions of both benefits and risks of agricultural childhoods.

KEYWORDS

health, safety, children, youth, livestock, risk, agriculture, anthropology

1. Introduction

Growing up around livestock on a farm or ranch comes with both benefits and risks—a combination Bendixsen (1) has called the farm kid paradox. The paradox is that "certain aspects of farm life that expose children to harm are also linked to positive health outcomes." Rural upbringings may produce various physical, cognitive, and skill development benefits including a strong work ethic and problem-solving abilities. Recent research suggests measurable immunological benefits as well (2–17). Yet, growing up on a farm or ranch also involves risks to safety and health from interactions with livestock, machinery, chemicals, and other aspects of home environments that are also often workplaces, involving both work and play (18, 19). According to the National Farm Medicine Center, a child dies in an agriculture-related incident about once every 3 days and thousands of children are injured each year (20). Keeping children alive and thriving in vibrant rural communities is a common goal for both parents and advocates of agricultural safety and health. Supporting and effectively communicating with parents requires a deeper understanding of their needs, constraints, values, and lives. So, for those who want to see children continue to grow up on farms and ranches—and who also want to see fewer debilitating injuries and death among children—the question of how parents perceive benefits and risks is important.

In our research, we have explored how farm and ranch parents think about the benefits and risks of raising children around livestock, why they think it is important, how they make decisions, and other questions designed to understand their perspectives and experiences. What is it like to raise kids and livestock at the same time, and what do parents have to say about how to do it safely?

Our work builds on previous biomedical research on respiratory and immunological health impacts of childhood livestock exposure as noted above, anthropological research exploring questions about how we think and talk about occupational risk (21, 22), translational research on tailoring safety and health information (23–26), along with literature on the relevance and importance of culture in agricultural safety and health research (1, 27–31). We also use the Socio-Ecological Model (SEM) as a conceptual framework for thinking about the embeddedness of farm and ranch families in broader levels of social organization. This model helped to guide research design by focusing our attention not only on parents and their children, but also agricultural professionals and organizations at multiple levels. It complements our anthropological understanding of the complex ecological, social, and cultural dynamics of human behavior and reminds us to explore potential opportunities for interventions at multiple scales (32).

2. Design and methods

In 2021 and 2022, we conducted semi-structured interviews (33) with 30 beef producing farm and ranch parents in Kansas, as well as a free listing activity (33, 34) with 10 of these participants. In this activity, we had them describe child-livestock interactions by listing activities (both work and play) that their children perform with cattle, along with perceived benefits and potential risks. This research is part of a larger anthropological study that also involves dairy-operating parents in multiple states, along with agricultural health and safety professionals and others related to youth and livestock. In addition to visiting farms and ranches, we also utilized rapid ethnographic assessment techniques (35) to observe child-livestock interactions and interact with both parents and professionals in the context of county fairs in Kansas and Nebraska.

We recruited research participants through a Kansas State University extension network, at a local county fair, and through personal connections in rural communities surrounding Manhattan, Kansas. This recruitment process and the research, in general, were shaped and strengthened by our team members' rural and agricultural backgrounds and experiences, which inform our understanding of what it is like to grow up on a farm, ranch, or in a rural community.

Interviews took place in participants' homes, on their farms or ranchland, at workplaces, in public spaces, and online *via* videoconferencing due to the constraints of COVID-19. Each interview typically lasted around 45–60 min and sometimes involved additional conversation and tours of farms and livestock. We recorded field notes during visits and created written lists with some participants to visualize and engage in the free-listing activity together. Participants received informational handouts about the project and provided signed informed consent prior to interviews, which were recorded and transcribed. They were offered and later mailed compensation for completing the interviews as a gesture of appreciation.

Our analysis in this report is based on the narratives and perspectives of parents collected through semi-structured interviews and their discussions of perceived benefits and risks during the free listing activity. The data from free listing, however, will be subjected to more formal qualitative and quantitative analysis involving pile sorting in later stages of our project. We analyzed and interpreted the resulting data through an iterative process of immersion and crystallization (36) involving repeated team-based discussions and triangulation, along with feedback from external scientific advisors. Based on the qualitative data analysis process outlined by Babchuk (37), our approach also involved the identification and interpretation of multiple themes and patterns emerging from memoing, open coding, the categorization of codes, and the generation of themes from categories. We critically examined and discussed these interpretations as a team and invited feedback from peers and parents associated with agriculture.

3. Findings

3.1. Parents produce a continuum of child-livestock interactions

The Kansas farm and ranch parents we met in this study all raise children and cattle. They are all beef producers—with at least one head of cattle—and at least one kid between the ages of 10–18. We prioritized families that lived on farms and ranches, many of which turned out to be relatively diversified operations involving cattle, horses, pigs, goats, sheep, poultry, hay, and other crops and animals. Many of the children in these families raise and care for 4-H or FFA show animals and often form social networks with other farm families. The families consisted of two to five children, with an average of around three (2.9) children. Operations ranged in size from small-scale "hobby farms" (<20 acres) to much larger-scale commercial livestock and crop production (around 4,000 acres). Most families live in the eastern half of Kansas and many own and/or rent land in the Flint Hills, a unique tallgrass prairie ecoregion with a mosaic of grasslands, woodlands, streams, hills, and both grazing and cropland. Importantly, the beef producing parents in our study are not agricultural workers hired by farms and ranches, who experience different levels of agency and precarity. We are also not focused on parents whose children are hired employees on others' agricultural operations.

On one end of the spectrum, we met a family living on 20 acres on the outskirts of Kansas City, a major urban center, with one cow-calf pair, alpacas, chickens, and rabbits for 4-H, where the father worked off the farm and the mother home-schooled their daughter, who cared for show animals and played in the woods on the property. Another similar family lived on <10 acres outside Manhattan, with several horses and cattle for show in 4-H. On the other end of the spectrum, we met parents involved in multi-generational family farms and ranches, often with multiple properties, interests, and areas of commercial operation. We interviewed, for example, a full-time cow-calf producer raising four children on 3,000 acres in the Flint Hills, specializing in high-value breeding and genetics. We also spoke with a mother whose husband and four children live on a 360-acre diversified farm and work on their family's multi-generational, 4,000-acre commercial crop and cattle operation. In general, we met parents raising children on farms and ranches of varying sizes, interacting

with cattle and often an assortment of other animals for show, personal consumption, commercial production, and a variety of other reasons including personal enjoyment, hobbies, work, and learning opportunities. We met beginning farmers with off-farm employment and full-time farmers and ranchers with agricultural backgrounds and livelihoods—and a range of people in between.

We found that this spectrum of farm and ranch operations produces a continuum of child-livestock interactions. While some children are primarily involved in the care of show or hobby animals, others are much more integrated into the economic system of family farms and ranches. Some parents described the important contributions and intricate involvement of their children in the work of livestock production and agricultural operations. These tasks included cattle handling and processing, along with the use of horses, equipment, vehicles, and other machinery. In some families, children played an active role in the division of labor and systems of production on family farms and ranches.

3.2. Parents share similar motivations

While parents differed in the extent to which they involve children in livestock production and other aspects of farm and ranch work, they expressed similar motivations and a common intentionality in their decisions to raise their children around livestock. Whether they chose to raise children on a small-scale, less commercially oriented farm, or they continue a family tradition of agricultural production, parents described their lifestyle as an intentional decision to provide children with opportunities and benefits associated with farm and ranch life. As one couple explained, raising their four children on 23 acres of hilly pasture with "a handful of cows," two dozen goats, rabbits, chickens, ducks, dogs, and cats provides opportunities to work and have responsibilities, to learn about biology and animal husbandry, and to connect with their land and livelihood.

We also found that parents are motivated by a shared desire to cultivate certain kinds of learning opportunities and raise children to become certain kinds of people. Parents expressed value in teaching and learning through work, hands-on experience, interactions with animals, and some exposure to risk and challenges. They also discussed the importance of connections to food systems, land, and non-human species. These transformational experiences are envisioned as a foundation for producing people with a strong work ethic, practical skills, self-reliance, responsibility, and other traits conducive to the continuation of an agricultural way of life and other forms of demanding labor in our modern world. Child-livestock interactions are viewed by parents as part of this process of preparing children to survive, thrive, and contribute to society. As one father exclaimed, "We want to make dang sure that they are a good person in society."

3.3. Parents perceive a multitude of benefits

In our interviews, parents described a multitude of reasons why raising children around livestock is important, listing the many benefits that these interactions provide. Parents perceived this intertwined upbringing to be important because it introduces and prepares children for agricultural work and ways of making a living, promotes an active outdoor lifestyle, develops valuable skills and capabilities, fosters connections to food and places, passes along tradition, and instills values and character. Some of the other benefits of growing up around livestock that were commonly listed by parents include:

- Responsibility.
- Work ethic.
- Discipline, persistence, and delayed gratification.
- Knowledge of life cycles, life and death, biology, and science.
- Understanding of loss.
- Decision-making abilities and time management.
- Public speaking abilities (from showing and speaking to judges and other adults).
- Ability to deal with loss, failure, and disappointment.
- Situational awareness.
- Attention to detail.
- Self-reliance and independence.
- Ability to use and care for machinery and tools, including horses.
- Animal handling skills and knowledge of animal behavior.
- Exposure to animals and compassionate relationships with animals.
- Physical strength.
- Fun and family togetherness.
- Access to the outdoors and rural environments.
- Financial management and math skills.
- Problem-solving skills.
- Pride, confidence, and a sense of accomplishment.
- Exposure to diverse experiences.

Parents often described raising children and livestock at the same time as rewarding. Of course, some parents discussed the challenges of keeping children safe, motivating them to do chores, and balancing farm life with the demands of school, sports, and other activities. Despite the challenges of parenting on farms and ranches, we heard often about a multitude of benefits and the pride parents felt in the quality of people their kids were becoming.

3.4. Parents believe benefits outweigh potential risks

In addition to benefits, parents listed various potential risks associated with raising children around livestock. While some parents perceived a low level of risk to their childrens' safety and health, most parents easily identified and described in detail the risks of livestock handling, horseback riding, large and unpredictable animals, the use of tools, equipment, and machinery, and other aspects of farm and ranch life. These included risks, for example, of smashed fingers and toes, kicks from livestock, trampling, and injuries from horse or vehicle accidents. Some parents discussed their worries of potentially serious injuries and concerns about safety, but the most common theme we heard is that the benefits of growing up around livestock on a farm or ranch outweigh the risks.

As one mother told us, raising children around livestock is "a balance." This idea of balancing benefits and risks is a common way that parents talked about the challenge of providing learning opportunities with enough exposure to risk to produce benefits, while avoiding severe injury or death. She explained that, as parents, they

"recognize those risks but understand that, at least in our minds, those benefits that the kids are gonna get outweigh those risks." The objective then, as other parents discussed as well, is to "manage those risks so the benefits outweigh it."

To strike this balance and manage risk, parents described a range of decision-making strategies including assessing age and strength, incremental responsibility and exposure, hands-on mentoring, role-modeling, and monitoring. For some parents, decisions about the activities children perform on the farm or ranch are at least partially determined by what needs to get done. The common narrative, however, was that the benefits of child-livestock interactions outweigh potential risks.

3.5. Parents see limited exposure to risk as a benefit

Another key reason why farm and ranch parents believe benefits outweigh potential risks is that, not only is exposure to risk an important part of learning, but it is also one of the benefits of growing up on a farm or ranch. Exposure to the various risks, challenges, and occasional failures associated with caring for livestock is seen by many parents as beneficial for the development of the skills, characteristics, and resiliency that they value and strive to cultivate in their children. Consequently, we did not encounter parents who prioritized eliminating risk or preventing all injuries. Instead, we heard that some injuries are expected and acceptable, and sometimes opportunities to learn and improve. Exposure to risk and some level of injury, we heard, might make children safer.

As one parent told us, her children might be safer "because they're exposed to more." Others, for example, expressed beliefs that their kids' exposure to farm vehicles will make them safer drivers, and that limited and controlled exposure to livestock at a young age will make them safer, more aware, and more capable of handling risks of livestock in the future.

One rancher we met told his children who show cattle that, "You're gonna get stepped on. You're gonna get kicked. It's just part of it."

Another mother recalled how her son gained a "healthy fear" and learned a valuable lesson about attention, respect, and cattle handling after a kick by a calf. Her story served to illustrate how exposure to risk can be seen as a benefit in certain situations, and how benefits can be seen to outweigh risks. This incident, in which her son was kicked but not severely injured, was "a learning experience," she explained. "It's just like with anything, there are risks with it but the experiences and the knowledge that they've gained from having these animals, to us, most definitely outweighs [the risk]."

4. Discussion and conclusion

Our findings suggest that farm and ranch parents in Kansas are not naïve to the idea that raising children around livestock inherently involves a combination of benefits and risks, or that certain aspects of farm life expose children to harm while also producing positive outcomes. Instead, parents described this combination in rich detail as they discussed the ways their children interact with cattle and take part in everyday farm or ranch life. Parents articulated the value of child-livestock interactions and the intentionality of an agricultural way of life that produces diverse opportunities to learn, grow, and become valuable members of society.

As one parent noted, family farms are seen as environments "naturally conducive" to exposing children to experiences that develop valuable skills and instill certain qualities and characteristics. Exposure to risk and even some level of injury is accepted and, in fact, valued as a pedagogical approach and parenting philosophy. Parents talked about balancing or calculating risk, and they expressed awareness of various risks to their children performing a wide array of tasks. Many of the parents we interviewed also viewed exposure to risk as a benefit—sometimes even as a sort of gift shared among parents, children, and animals. This means that benefits and risks are not necessarily dichotomous, but rather much more complex and interwoven in the minds and lives of farm and ranch families.

In other words, some exposure to risk, challenging situations, and diverse experiences—along with some level of non-fatal and non-debilitating injury—is actually seen as a benefit since it entails vital opportunities to learn, develop, and perhaps become safer in the long-term. This perspective is part of a shared vision of the kinds of humans that parents are trying to raise—ones with character and a strong work ethic, practical and valuable skill sets, self-reliance, responsibility, sound judgment, and other traits needed to sustain agricultural heritage and ways of life, or to survive and thrive in other demanding jobs and precarious times. Perhaps most importantly, parents believe that the benefits of child-livestock interactions outweigh potential risks.

Understanding how farm and ranch parents perceive the benefits and risks of child-livestock interactions may help to bridge cultural and communication gaps between rural communities and agricultural safety and health professionals. This knowledge and cultural competence may also improve the design, trustworthiness, and adoptability of injury prevention messaging and intervention strategies, including work guidelines and other recommendations for parents (38–40). One of the strengths of our anthropological approach is that it focuses on child-livestock interactions from the point of view of parents, but our findings are also limited to parent perspectives and experiences, as opposed to those of children. The amount of time we spent on farms and ranches was also limited, constraining opportunities for observations and participation in ordinary family life.

Nevertheless, to translate injury prevention materials and make agricultural health and safety resources more meaningful for parents, our work suggests that because parents emphasize benefits, understanding and incorporating the perceived benefits of child-livestock interactions may be key. Focusing only on potential risks—or on the elimination of all possible opportunities for injury—may alienate farm and ranch parents by obscuring how and why they choose to raise children around livestock, and what doing so safely means to them. Acknowledging the multitude of perceived benefits that come from working and growing up on a farm or ranch is one plausible step toward more effective and culturally sensitive communication with parents and rural communities.

A takeaway from this research is that for ideas about how to prevent debilitating injuries and death of children on farms and ranches to reach and impact parents, it may be essential to recognize how they perceive and balance both the benefits and risks of child-livestock interactions, and why they desire and cultivate an agricultural childhood for their families. Supporting parents in their efforts to raise both healthy children and livestock at the same time

may also involve envisioning the kinds of humans and society they seek to shape.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This study involving human participants was reviewed and approved by Kansas State University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

Author contributions

RK conducted data collection and led latter stages of analysis and interpretation. RK and TD contributed to the conceptualization and writing of the article. All authors contributed to the production of this manuscript, research design and methodology, data analysis and interpretation, review, editing, preparation, and approval of the submitted manuscript.

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Conflict of interest

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Safeguarding youth from agricultural injury and illness: The United States' experience

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Background

The United States of America (US) is a country of 50 states with a population of more than 335 million people in 2022 (1). Across the expansive geography, there are ~2.1 million farms (2), with about 890,000 youth younger than 20 years old living and working on family farms, plus another 265,000 non-resident youth hired to work on farms each year (3). The tremendous diversity in US farm locations, size, commodities, machinery, and livestock is associated with a wide range of work assignments and risk exposures for young people of all ages. Occupational fatality data from the last decade indicate that, across all industries, agriculture had the leading number of work-related deaths for youth. Further, within the agricultural industry, youth between the ages of 10 and 15 suffered the most non-fatal work-related injuries (4). Although there are no official agricultural injury statistics for youth in the US, a 2014 government analysis estimated an annual 12,000 non-fatal injuries among youth and, of these, about 2/3 involved non-working youth, that is, individuals in the farm environment, but not actively engaged in the work itself (5). Leading causes of fatal and non-fatal injuries for both working and non-working youth are vehicles (including tractors, all-terrain vehicles, skid steer loaders), machinery, and contact with animals.[1]

Agricultural environments also include health risks that are compounded for youth in relation to their physical development stage. Concerns include exposures such as organic dusts, airborne pollutants, pesticides, toxic gases, and cleaning agents. Additionally, there are risks associated with heat-related illness, animal-transmitted infections, noise-induced hearing loss, musculoskeletal strains, sun exposure, and mental health (6).

The US child labor laws and policies are less restrictive than many international standards and are less restrictive for agriculture compared to other occupations. For example, the Fair Labor Standards Act (FLSA) allows youth starting at 12 years to be employed for farm work with unlimited hours, providing they have parental permission and continue to attend school. Family farms account for 96% of all US farms, and parents and guardians are exempt from compliance with the FLSA rules when their children are working on their own farms. The Child Labor in Agriculture Rules (https://www.dol.gov/sites/dolgov/files/WHD/legacy/files/childlabor102.pdf), including a list of Hazardous Occupation Orders restricting certain activities until age 16, have existed for nearly 40 years, and efforts to update them in 2011 were ceased primarily due to strong backlash from groups within the farming community (7, 8). Another difference in the US compared to many industrialized countries is the limited government support for working parents. Further, the US offers no universal paid parental leave, while childcare access in rural areas is both sparse and expensive (9, 10). These factors likely contribute to the increased presence of young children in agricultural work settings.

1 In the US, the terms child, children and/or youth typically refer to any individual or groups younger than 18 years old. Some data sources refer to specific age groups and are such reported here. However, when the general term "youth" or "children" is used, it is interchangeable and implies individuals 0 through 17 years.

Current activities

Since 1996, the US government, under leadership of the National Institute for Occupational Safety and Health (NIOSH), has supported research and interventions to address the complex factors contributing to preventable diseases and injuries affecting working and non-working children *via* a National Action Plan (11). Funds are allocated for independent research as well as support for a national coordinating center—the National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS).

Many US organizations are promoting childhood agricultural safety and health, with NCCRAHS recognized as the national leader (12). Partnerships and collaborations are key to carrying out this work (12). Beginning in the 1990s, an important first step for interventions was the creation of voluntary guidelines for assigning youth work and building safe play areas for children on farms. Guidelines for agritourism (groups of children visiting on farms), media relations, and off-farm childcare followed in later years. Guidelines were drafted, refined and subsequently updated *via* consensus-development processes and/or advisory committees. Several were evaluated for their effectiveness and implementation strategies (13). All are available online, along with safety checklists, brochures, and public service campaign materials.

While NCCRAHS primarily targets strategies with farm parents, supervisors, and organizations that work directly with producers, other organizations such as Progressive Agriculture Foundation™ offer safety programs directly for children, with messages and demonstrations to convey principles of safety. "Safety Day" evaluations have shown their effectiveness (https://www.progressiveag.org/Success.cgi). Other relevant groups include AgriSafe and Ag Safety & Health Alliance that deliver programs for high school youth and college students.

The US Department of Agriculture (USDA) allocates funds for a national Safety for Agricultural Youth (SAY) online clearinghouse of work-related curricula, developed through a collaboration between Penn State, the Ohio State, University of Utah and Purdue University (ag-safety.extension.org/say-national-clearinghouse/). USDA also supports youth tractor certification courses delivered by state land grant institutions and county-level Extension services.

From 1998 to 2014 the US government systematically collected and reported childhood agricultural injury data providing empirical evidence on demographics, injury agents and trends (3). When that system ceased, AgInjuryNews.org was developed as a free, online, searchable database of publicly available news reports of youth and adult agriculture-related injuries; and is now expanding to include international data (14).

Beyond resources and injury data, many NIOSH-funded centers allocate funds for external projects through small grants programs for community-based organizations and/or junior faculty to build capacity in the discipline. In-person and virtual safety workshops and training events are collaborative efforts of NCCRAHS, Progressive Ag Foundation™, AgriSafe, the 11 regional NIOSH-funded agricultural centers, and several international partners. Nearly all organizations promote farm safety and health *via* social media, press releases, interviews, and conference presentations.

In 2009, the Childhood Agricultural Safety Network (CASN) (https://cultivatesafety.org/casn/) was established as a loose-knit coalition of child safety advocates, farm safety professionals, youth-serving organizations, health care providers, insurance agencies, and farm media. Coordinated by NCCRAHS, network members collaborate on education and outreach projects, including developing and disseminating public service campaigns on topics like "no extra riders on tractors" and ATV/UTV safety. Last year, CASN launched an online community to facilitate communication and collaborations. CASN has grown from an initial three to nearly 200 organizations in 2022, including 10 international members.

Impacts and challenges

Over these past 25 years, there have been many accomplishments. Data showed a 60% decline in non-fatal childhood agricultural injuries from 2001 to 2014 (3). A national report placed the Childhood Agricultural Injury Prevention Initiative among the occupational safety "top 10" public health successes of the decade (15). Research confirmed the impact of work guidelines, demonstrating a 50% reduction in injuries where children's tasks were assigned per the guidelines (16). Funding has grown beyond NIOSH and USDA to include substantial private sector and agribusiness sponsorship of education, conferences and outreach efforts (17). Most importantly, positive impacts are attributed to the coordination and collaboration of many organizations raising the profile of childhood agricultural safety and health *via* education, training, interventions, and accessible resources.

Yet for all these accomplishments, challenges and gaps still persist. Myriad factors contribute to decisions regarding youth work on farms as well as presence of small children in the work setting. Farm parents often weigh the benefits of living and working on a farm with the risks of disease and injury in a concept known as the "Farm Kid Paradox" (18). Despite the evidence, studies reveal that some parents do not view the farm environment as dangerous and do not perceive their own children to be at risk of injury (19, 20). Another study revealed that parents often refer to "common sense" even when they are not modeling safe behaviors themselves (21). In contrast, some parents would prefer to keep children away from agricultural work areas, but have few alternatives because of the need to keep the farm operational amidst a lack of affordable and accessible childcare (22, 23). Adding to this is the challenge of reaching unique populations that harbor traditional practices and religious views regarding youth on farms, such as Plain communities (24). Furthermore, factors that compromise adults' safety behaviors have been exacerbated by the COVID-19 pandemic, their socio-economic status, and unstable labor markets (25).

A major challenge is the country's current child labor laws and policies that, if updated to be consistent with non-ag industries, could significantly reduce work-related child injuries and fatalities (26). Another concern is absence of timely, valid, and reliable injury data, especially since NIOSH's discontinuation of its Child Ag Injury Surveillance program (27). Also, the increasing use of small farm machinery, such as ATVs, UTVs, and skid steers has heightened risk exposures (28). Yet another challenge is the hesitancy of local officials, including Child Protective Services and District Attorneys, to hold adults accountable for endangering children in farm settings. On average only two childhood agricultural fatality or traumatic injury cases per year (of an estimated 100 deaths and 12,000 injuries/year) result in an adult being legally charged with a penalty for endangering or neglecting a child in a dangerous environment (29). To resolve

these gaps and challenges we will need major financial investments, public policy, and "buy-in" from influential farm organizations.

Future directions

Future attention must account for the ever-changing work practices, technologies, and risks of production agriculture, while respecting safe traditions, cultural beliefs, and social norms. To this end, the Socio-Ecologic Model (SEM) is an ideal framework for implementing youth agricultural safety and health strategies. The process encourages repeated approaches involving agents of influence at multiple levels—from individuals (e.g., parents), through community members (e.g., schools, churches), up to policymakers (30). This model incorporates perspectives from multiple angles toward a common goal.

National-level US approaches are dependent on government leadership with bipartisan support and involvement of agricultural stakeholders, but it is uncertain if that level of commitment will materialize, given other pressing priorities. The US' outdated child labor regulations, limited childcare services and labor shortages will continue to impact children's exposures to hazards on farms. Further, filling the childhood agricultural injury data gaps will require substantial funding and coordination across the many geographic regions. In addition to data, research is needed to better understand the barriers and motivators that influence parents' and supervisors' decisions to implement youth safety practices such as use of work or play guidelines.

Across the many US organizations, our goal continues to be the enhancement of health, safety, and wellbeing of all children living on, working on, and visiting US farms and ranches. We will continue to work collaboratively until every child is safeguarded from preventable disease and injury associated with agricultural environments.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Do social influences, awareness, or experience matter? Toward a better understanding of Farm-related Injury Risk Perception among agricultural science college students in Ireland

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Introduction: Formal farm safety education/training should be tailored, in terms of the approach, content and delivery, to students undertaking agriculture education and training to enhance Farm-related Injury Risk Perception (FIRP). To this end, this paper assesses factor(s) explaining or predicting levels of FIRP amongst students studying for a degree in agriculture science.

Methods: A cross-sectional online survey was conducted with a nationally representative sample of Bachelor of Agriculture Science (BAgrSc) students ($N = 417$) (aged 18–20) in Ireland. Descriptive [frequency and cross-tabulations) and inferential (Ordinal Logistic Regression (OLR)] analyses were applied to evaluate the effects of social influences, experience (of farming, of a near-miss or injury), and awareness (of others who were injured or killed on the farm) on FIRP.

Results: The study found that social influences negatively affected FIRP ($P < 0.05$). A relatively small number of students reported experiencing an injury ($n = 56$, 13.4%) that resulted in them being unable to participate in educational or social activities. A quarter of the respondents did, however, record experiencing a near-miss/close call ($n = 106$, 25.4%). A notable proportion ($n = 144$, 34.5%) of students had personal connections to someone who died as a consequence of a farm-related incident and 56.4% ($n = 235$) knew someone who was moderately or severely injured. OLR findings established that experiencing a severe injury, having a near-miss or close call, and awareness of a farm-related death or injury positively affects FIRP ($P < 0.05$).

Conclusions: Perception of farm risks amongst students in Ireland is low. Students who recorded higher levels of risk perception were, however, more likely to report experiencing a near-miss, close call or severe injury, or knowing someone who experienced a farm-related injury or fatality. Farmers, family or friends were found to negatively impact the FIRP and this reflects previous research findings. Our findings highlight the need for education and training programs to enhance opportunities for student peer-to-peer learning through sharing of experiences and/or knowledge of farm injuries and/or fatalities. Such activities will enhance awareness and understanding amongst the general population of students leading to increased FIRP and contribute to a reduction in risk-taking.

KEYWORDS

Farm-related Injury Risk Perception, experience, awareness, social influences, youth, students, Ireland

1. Introduction

Farmers may conscientiously avoid risks if they perceive a higher chance of injury associated with a practice, situation or behavior (1–4). As such, Farm Injury Risk Perception (FIRP) is a key factor which modulates risk taking behavior (5–7) that is distinct to the awareness of the risk, i.e., a person may be aware of a risk yet still engage in a behavior or practice that heightens the possibility of experiencing an injury because they believe themselves to be safe (2, 4, 7). For instance, a farmer may identify dangers associated with animal or tractor/machinery related tasks while perceiving a lower chance of an incidence occurring because they are familiar with the livestock or are experienced operating the machinery (optimistic FIRP) (2, 8–10). In addition to the individual's experience, risk perception and tolerance of risk is also influenced by the social context, i.e., attitudes of family, friends and peers, and the organizational context, i.e., expected behaviors or norms (11–14).

In family farm settings, young adults are one of the main vulnerable groups for farm injury (15, 16). This is explained by a combination of factors including the tendency for the residence and workplace to be in close proximity, a tendency for youth and young adults to work on the farm and take risks (17, 18), and the acceptance of risks amongst farm families (19, 20). Whilst regulatory and educational approaches to increase safety on farms do consider a variety of populations, young adults are generally not the primary focus of such interventions (16, 21–28). An assessment of non-fatal farm incident data indicates that this cohort experiences high levels of injuries or close calls, something that is attributed to higher levels of risk taking (16, 28–34). These data point to the need for FHS initiatives and educational programs targeting young farmers to improve or increase risk perception. A key barrier to the development of education and training courses targeting this population is the absence of research into their appreciation or understanding of key risks they may encounter whilst living or working on a farm. To inform the development of these interventions there is a need for a better understanding of factor(s) explaining or predicting levels of FIRP. Currently, the level of FIRP and the contributory factors among young farmers is something of a "black box" as there is limited research on FIRP (3, 35–37). Accordingly, this paper seeks to identify the predictors (individual, social influences, awareness, and experience) of FIRP amongst a nationally representative population of young adults participating in a BAgrSc course and develop recommendations informing the content and delivery of effective farm safety education and training. Before presenting the approach (methods and data) and results, we map out the conceptual links between FIRP and farmer experience, social influences, and awareness of injuries/fatalities below and specify three core hypotheses. These guide the data collection, choice of methods, analysis and interpretation of results that are reported in the remainder of the paper.

1.1. Theoretical framework and hypotheses

1.1.1. Farming experience

According to the literature, to explain the relationship between "farming experiences" and FIRP, in particular among young farmers, it is necessary to understand the extent to which farming experience matters. Within the literature, the role of experience has been reported to have negative and positive influences on risk perception. One body of research finds that experienced farmers with higher working skills and managing/undertaking multiple farming tasks, may have a better judgement of the chance of injury associated with an activity and consequently be more risk averse (35, 38, 39). Another body of research presents evidence indicating experienced farmers may have lower FIRP due to a belief that they are more skilled and capable of controlling risks (4, 9, 40). As such, farming experience might be either positively or negatively associated with the FIRP.

Among young farmers, the same findings have been reported. Limited farming experience is one of the factors associated with the underestimation of risks by young farmers (2, 35). New entrants to farming, even those from a farming background, have been found to have a relatively low appreciation of the occupational risks they face (19). Notwithstanding this, growing up on farms and having greater farming experience may not necessarily be positive as it can contribute to maladaptive behaviors or overconfidence (14, 36). It is also acknowledged that as younger farmers gain experience or age, they are given more responsibility for additional tasks. Whilst these tasks may be riskier in and of themselves, the increased workload and greater time working, frequently on their own, represents risks (9, 14, 41, 42).

Based on the current literature it is uncertain how or to what extent experience of farming shapes the FIRP of young farmers and this informs our first hypothesis:

> H1a: Farming experience is positively associated with higher levels of FIRP among young farmers.

1.1.2. Experience of injury or near miss/close call and injury experience

Apart from general farming experience, the experience of a farm-related incident or injury including a near miss or close call is considered a key factor contributing to FIRP and, consequently, risk prevention behavior (7, 9, 36, 43). A number of studies have found that farmers who experienced a near miss were more risk adverse (44–46). Similarly, being injured as a consequence of risk taking behavior may positively shape FIRP as farmers learn from the experience (4, 9, 28, 43, 47). There is some evidence that the positive impact a recent experience of a near miss/close call may have on FIPR can weaken over time (9).

In contrast to this body of research, other studies have highlighted that experiencing a near miss or close call may negatively influence FIRP (44–46, 48) as individuals perceive a lower chance of severe injury and a higher level of control over such situations in the future. It is also argued that farmers may take additional risks if they experienced a minor injury or near miss/close call (9, 42). When it comes to younger farmers, this factor might be even more important as this population are less likely to experience severe injury and more likely to experience a near miss/ close call which may negatively affect the level of FIRP (16, 32–34). There is, however, no clear evidence regarding the impact of experiencing a near miss or close call on the risk perception of younger farmers. This informs the development of two related hypotheses which are tested below:

> H1b: The experience of a near miss or close call will positively affect FIRP among young farmers.
> H1c: The experience of a severe farm-related injury will positively affect FIRP among young farmers.

1.1.3. Social influences

In addition to individual experience of farming, social influences are recognized as playing a significant role in the formation of FIRP (49, 50). Culturally, risk-taking may be considered a "social value" and thus is accepted and normalized as "what a farmer is expected to do" (19, 42, 51). Some research implies that FIRP is built up through social confirmation or pressure from key people or referents named as "important others" both within the household and the wider social or community network (13, 20, 52). Young farmers are particularly influenced by family members including parents, grandparents, uncles, aunts etc. (36, 39, 41, 50). This influence works in two ways, firstly through transmission of views on what constitutes a risk and the levels of 'acceptable' risk associated with different practices (2, 13, 36, 52), and secondly, social pressure to adopt risky behaviors (4, 20, 49, 53), e.g., operating machinery or working with livestock without adequate training or protective equipment/facilities which are commonly perceived to result in higher economic returns (2, 9, 14, 36). Engaging in risky activities is also seen as a way of accruing cultural capital amongst peers, including other farmers and friends, i.e., demonstrating that they are "authentic" farmers (4, 19, 38). Counterbalancing these potentially negative influences, young farmers are also exposed to a range of other social influences, e.g., lecturers or farm advisors who hold positions of authority and, consequently, may be in a strong position to positively influence FIRP. In order to assess the effect of the variety of social influences on FIRP this study examines the following hypotheses:

H2a: Social influences from (a) family/friends and (b) farmers will negatively affect FIRP among young farmers.
H2b: Social influences from lectures/advisors (c) will positively affect FIRP among young farmers.

1.1.4. Awareness of farm related injury/fatal incidents

Farmers who know someone who died or was injured as a consequence of a farm incident are more risk averse than the general population of farmers (13, 14, 31, 44). Notwithstanding this, there is a knowledge deficit in understanding to what extent hearing about or knowing someone who has been injured/killed as a result of an incident affects FIRP, particularly among young farmers. Accordingly, the following hypothesis is examined in this study:

H3: Knowing someone who was: (a) injured; or (b) killed, resulting from a farm-related incident positively affects FIRP among young farmers.

2. Materials and methods

2.1. Participants

To test the study hypotheses, this study applied a cross-sectional quantitative approach. First and second year undergraduate students enrolled in agriculture related education courses at the School of Agriculture and Food Science in University College Dublin (UCD), formed the target population. This population was selected as these students generally come from farm families, though not in every case, and generally go on to work as farmers or within the wider agriculture sector that supports farm businesses e.g., farm extension services, financial services, or agri-food businesses (54). The exclusion of third or fourth year students avoided a potential effect/bias as these have to complete a "Health, Welfare, and Safety" module prior to engaging in professional work experience placements in third year.

2.2. Procedure

To recruit a representative sample of this population, according to Kerjcy and Morgan's (55) sampling equation,

$$S = X^2NP(1-P)/\ d^2\ \ (N-1) + \ X^2P(1-P) \qquad (1)$$

Where S is the required sample size, X equates to Z value (1.96 for 95% confidence level), N refers to the population size which is all Bachelor of Agricultural Science (BAgrSc) students ($N = 545$), and P is the population proportion (considered as a decimal) (assumed to be 0.5 (50%), and d is margin of error (5%), (expressed as a proportion (0.05)). This provides an estimate of a minimum of 148 students needed as the sample size (95% confidence level). To access this population we distributed the survey using the online Survey Monkey platform to lecturers who, in turn, raised awareness of the survey amongst the target population. The authors sought ethical exemption, which was granted and a letter of permission from the Head of School provided. In applying for the exemption, the authors set out the potential ethical issues relating to the proposed research and the protocols that were put in place. The design of the survey reflected this and took into consideration the potential that some questions, particularly those that asked about knowledge or experience of serious farm injuries or fatalities, had the potential to cause upset or anxiety to respondents. In anticipating this, prior to respondents answering any questions, we provided them with an outline of the types of questions and the issues covered in the survey, highlighted that they did not have to participate, could withdraw from the survey at any stage and could request that their data be removed from the analysis at any time. The anonymity of the participants was assured by not collecting any information that could be used to identify individuals. Finally, lecturers were asked to highlight resources and student support services available to students in the university. In total, 417 students completed the survey (Response rate = 76.5%) which was greater than the expected response rate for online surveys (33–47%) (56) and above the minimum sample required.

2.3. Measures

The survey comprised a number of distinct sections that are outlined below.

2.3.1. Demographic variables

Demographic variables included age, stage of university education (i.e., first or second year of study), and gender (male/female/prefer not to say).

2.3.2. Dependent and independent variables

2.3.2.1. FIRP (dependent variable)

FIRP may vary depending on different activities (7, 10). As a consequence FIRP was measured by four questions that assessed "general perception," questions 1 and 2, and perception of "specific" risks, questions 3 and 4, related to machinery and livestock. These specific risks correspond to the primary causes of fatal farm injuries in Ireland (15) and many other countries (57, 58),

1. *How likely or unlikely do you think it is that you may get injured whilst working on the farm? (FIRP1)*
2. *How likely or unlikely do you think it is that a family member may get injured on the farm? (FIRP2)*
3. *How likely or unlikely do you think it is that you may get injured whilst working with farm machinery, e.g., tractor, harvesting machines, quad etc.? (FIRP3)*
4. *How likely or unlikely do you think it is that you may get injured whilst working with livestock? (FIRP4)*

All items were measured using a 5-point Likert scale ranging from 1 "very unlikely" to 5 "very likely." Responses were categorized into one of three groups; "low FIRP" where respondents selected "very unlikely or unlikely"; medium if they selected "neutral FIRP"; or "high FIRP" if they chose "likely or very likely."

2.3.2.2. Independent variables

The independent variables consisted of estimates of the level of farming experience with response options ranging from "none" though to "a great deal." Experience of a near miss or close call was measured through two binary questions. Experience of an injury was assessed through a single binary question that asked if the respondent had been unable to participate in education or work activities for more than a day as a consequence of having a work related injury in the preceding 12 months. With regard to social influences, respondents were asked to rank in order of importance those who influence their decisions regarding farm safety issues. Response options included "family/friends, "farmers," "farm advisors/lecturer" and others. Subsequent questions sought to explore knowledge of someone who experienced a severe farm-related injury or fatality. We used two separate binary questions to assess knowing someone who "died" and knowing someone who was "severely injured."

2.4. The questionnaire validity and reliability

To validate the degree to which each variable is accurately measured by items/questions, the questionnaire was tested to ensure content and face validity. Following Engel et al. (59) recommendations, the identification of potential dependent and independent variables from the literature review preceded an evaluation of these by a panel of experts/researchers (59). The panel included three FHS specialists along with four behavioral and social scientists with a previous background in FHS studies. The content of each variable was reviewed and their validity assessed (59). The panel evaluated the face validity of each question, i.e., the degree to which questions measuring study variables were relevant to the target population (60). Questions were evaluated based on "feasibility, readability, consistency of style and formatting, and the clarity of the language used" (60).

To assess the face validity and reliability of the questionnaire items, a pilot study was undertaken among 54 college students that were participating in agricultural education. As there was no construct containing multiple ordinal/binary items to compute, a reliability test was not needed. However, this paper estimated Cronbach's alpha for FIRP (four items) (0.89) which was greater than the acceptable cut-off point (>0.7) (61).

During this phase of the research consideration was given to how to avoid optimistic or social desirability bias. A number of strategies were identified and implemented, including assuring students of their anonymity, and providing a brief overview of the study objectives that stressed the importance of factual, rather than desired, responses (62).

2.5. Statistics

2.5.1. Descriptive analysis

In the first step, frequencies and cross-tabulation analysis were conducted to describe the level of FIRP and distribution relative to the demographic and independent variables. Cross-tabulation analyses using Kendal tau b and c were applied to examine the correlations between both demographic and independent factors with FIRP. All variables which were found to be significantly associated with FIRP were entered into the regression model.

2.5.2. Ordinal Logistic Regression

FIRP comprises three ordinal categories, "low," "neutral," and "high." To assess the relationship with the independent variables, an Ordinal Logistic Regression (ORL) technique is applied. As the ordinal FIRP categories of "low," "neutral," and "high" were computed from five point Likert scales, the proportional odds model was applied (63). This technique explains the effects of exogenous nominal and ordinal variables on FIRP as an ordinal (dependent) variable by one regression coefficient (63). Accordingly, the regression findings are relatively easy to convey to a wider range of stakeholders who may not be familiar with this type of analysis (63).

Prior to testing the study hypotheses, the goodness of fit of the regression model was estimated (63). As the FIRP was an ordinal categorical variable with a limited number of categories (three), the Person chi-square statistic was applied to estimate the global goodness of fit of the regression model (63). To perform the analyses, SPSS for Windows (Version 27.0. Armonk, NY) (64) was used.

3. Results

3.1. Descriptive statistics

3.1.1. Characteristics of respondents

In terms of the sample, 45.8% ($n = 191$) and 54.2% ($n = 226$) were in first and second years of their BAgrSc, respectively. The median age of respondents was 19 years (mean = 18.91 ± 0.79). Just over half of respondents were female ($n = 222$, 53.2%). Describing the farming experience, over half of the students reported their level of engagement in farming activities as "A great deal" ($n = 222$, 53.2%), followed "quite a bit" ($n = 80$, 19.2%). In turn, students indicated

their farming experience as "Some" ($n = 46$, 11 %), "A little" ($n = 35$, 8.4%), and "None" ($n = 34$, 8.2%). As such, the majority of students are substantially engaged in farming activities (over 70%), and can be considered to be "young farmers."

One quarter ($N = 106$, 25.4%) of respondents reported experiencing a near-miss or close call over the previous 12 months. Of this number, 52 (49.06%) reported the primary cause of the incident involved livestock, 26 (24.52%) involved a tractor, 23 (21.67%) involved farm machinery, and 5 (4.21%) were recorded as "other." Only 58 (13.9%) students reported experiencing severe farm-related injuries resulting in being unable to participate in education or work activities for more than a day over the previous 12 months. Livestock ($n = 21$, 36.2%), farm machinery ($n = 18$, 31.03%), and tractors (13, 22.41%) were the three main causes of such incidents. Regarding students' awareness of farm injury/fatal incidents, more than half of the participants ($n = 235$, 56.4%) identified that they know someone who was injured as a result of a farm-related incident. Furthermore, 144 students (34.5%) reported that they know someone who died as a result of farm-related incidents. "Farmers" were identified as the key "important others" by nearly one-third of respondents ($n = 161$, 38.6%), followed by "family/friends" ($n = 140$, 33.6%). Finally, just 57 students (13.7%) identified "farm advisors/university lecturers" as the key "important others." Accordingly, farmers and family/friends are the key "important others" whose thoughts/views on FHS matter most to students.

3.1.2. Farm-related Injury Risk Perception

The responses of students to the FIRP questions were assessed and two distinct groups, those who are risk optimistic, i.e., they perceive lower levels of risk, and those who perceive higher levels of risk and are more risk averse. The absence of an intermediate group, i.e. those who are uncertain, suggests that risk perception is a construct with little room for ambiguity. Assessing the four measures used to assess FIRP, we find that the pattern of responses are broadly similar with, roughly 50–52% of respondents reporting lower levels of risk perception, 40–42% reporting higher levels, whilst 8%, on average, have neutral perceptions (Figure 1).

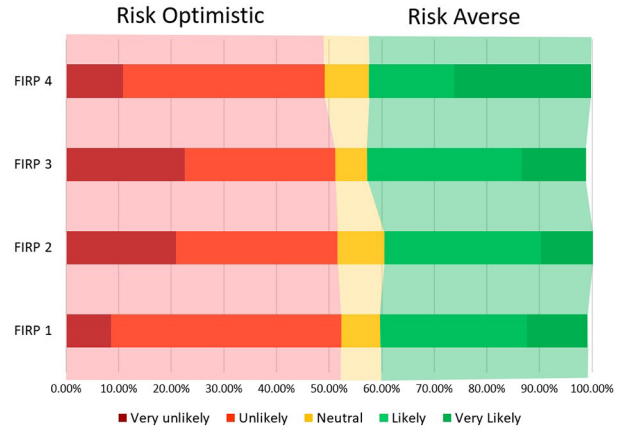

FIGURE 1
The level of the four FIRP dimensions.

3.2. Correlations

3.2.1. Background factors

Before analyzing the correlations between independent variables (experience, social influences, and awareness) and the four FIRP dimensions, this study examined if there are significant correlations between age, year of education, and FIRPs to identify and if necessary, control for any biases from these factors on the FIRPs. Regarding age, which was non-normally distributed (most students are the same age, mean = 18.91 ± 0.79), we used Kruskal-Wallis H Test to examine if there are any differences between the age of students who identified FIRPs to be "low," "neutral," and "high" and found that there is no significant difference between the age of students across the three risk cohorts and the four FIRP dimensions ($P > 0.05$). Therefore, we conclude that, with regards this sample, age was not a factor associated with students' judgement on the likelihood of farm-related injury incidents.

3.2.2. Farming experience

There was no significant association between "farming experience" and students' level of risk perception ($P = 0.16$–0.36). As such this finding leads us to reject H1a, i.e., that farming experience is positively associated with higher levels of FIRP among young farmers. Cross-tabulation analysis revealed that students with higher farming experience ("a great deal" and "quite a bit") are almost equally likely to be "risk optimistic" (ranging from 46.4 to 57.2%) or "risk averse" (37.9–44.1%) across all four FIRP dimensions (Tables 1–4). The same pattern was identified for students with most of the other levels of experience (Tables 1–4). The one group that stood out were those students who classified themselves as having "some" farming experience. Here we found that, depending on the FIRP, between 54.3 and 67.4% perceived lower risk of farm-related injury incidents, i.e., they were, in general, more optimistic than their counterparts. We found that students with "none" or "a little" farming experience are, in general, "risk optimistic" as over half of them perceived lower FIRPs.

3.2.3. Social influences

There was a statistically significant association between respondents who reported family/friends ($P = 0.001$–0.036) or farmers ($P = 0.001$) as the key "important others" and the level of each of the four FIRPs (Tables 1–4). We found students who are influenced by their family/friends are more likely to be "risk optimistic." The analysis establishes that the majority of this cohort (60.71–67.1) perceived a "low" level of FIRPs. This is similar to the proportion (ranging from 65.8% to 69.6% depending on the FIRP) of respondents who reported "farmers" as being a key influence (Tables 1–4). There was no significant association between students who reported "advisors/university lecturers" as the key social referents and the levels of FIRPs. These results lead us to accept H2a, i.e., that social influences from family/friends (a) and farmers (b), will negatively affect FIRP among young farmers, and reject H2b, i.e., that social influences from lectures/advisors (c) will positively affect FIRP among young farmers.

TABLE 1 Chi-square analysis between background and explanatory variables and FIRP1.

Variables		FIRP1 (likelihood of farm related injury occurrence while working on farm in general)						Stats
		Low (218, 52.3%)		Neutral (31, 7.4%)		High (168, 40.3%)		
		n	%	*n*	%	*n*	%	Test
Background variables	**Year of study**							
	First stage (191, 45.8%)	100	52.4	14	7.3	77	40.3	2.054
	Second stage (226, 54.2%)	118	52.2	17	7.5	91	40.3	
	Gender							
	Male (195, 46.8%)	103	52.8	16	8.2	76	39	0.47
	Female (222, 53.2%)	115	51.8	15	6.8	92	41.4	
	Farming experience							
	A great deal (222, 53.2%)	111	50	18	8.1	93	41.9	13.49
	Quite a bit (80, 19.2%)	40	50	6	7.5	34	42.5	
	Some (46, 11%)	31	67.4	4	8.7	11	23.9	
	A little (35, 8.4%)	23	65.7	2	5.7	10	28.6	
	None (34, 8.2%)	13	38.2	1	2.9	20	58.8	
Social influences	**a. Family/friends**							
	Yes (140, 33.6%)	94	67.1	12	8.6	34	23.6	6.35*
	No (277, 66.4%)	144	52.0	19	6.9	114	41.2	
	b. Farmers							
	Yes (161, 38.6%)	110	68.3	7	4.3	44	27.3	27.2***
	No (256, 61.4%)	108	42.2	24	9.4	124	48.4	
	c. Advisors/lecturers							
	Yes (57, 13.7%)	15	26.3	23	40.4	39	34.5	1.92***
	No (360, 86.3%)	203	56.4	28	7.8	129	35.8	
Experience	**Near miss/close call**							
	Yes (106, 25.4%)	9	8.5	1	0.9	96	90.6	149.4***
	No (311, 74.6%)	209	67.2	30	9.6	72	23.2	
	Severe injury							
	Yes (58, 13.9%)	1	0	0.0	0.0	57	98.3	94.17***
	No (359, 86.1%)	217	60.4	31	8.6	111	30.9	
Awareness	**Someone who injured**							
	Yes (235, 56.4%)	91	38.7	14	6.0	130	55.3	50.69***
	No (182, 43.6%)	127	69.8	17	9.3	38	20.9	
	Someone who died							
	Yes (144, 34.5%)	21	14.6	10	6.9	113	78.5	139***
	No (273, 65.5%)	197	72.2	21	7.7	55	20.1	

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

3.2.4. Experience of near miss/close call or severe injury

Experience of a "near miss/close call" ($P = 0.001$), and experiencing a "severe farm-related injury" ($P = 0.001$) were statistically significantly associated with the level of FIRPs leading us to accept H1b (Tables 1–4). Almost all students, $n = 106$ (25.4%), who have experienced a "near miss/close call" in the past year reported higher levels of FIRPs, i.e., ranging between 78.3% for livestock to 90.6% for general risks to self. Similarly, almost all students ($n = 58$) who have experience of a severe farm-related injury reported significantly ($P = 0.001$) higher FIRPs compared to others (Tables 1–4) leading us to accept H1c. In each FIRP, 98.3% of respondents reported "higher" risk perception. This result is interesting in that it suggests experiencing a severe injury impacts both general and

TABLE 2 Chi-square analysis between background and explanatory variables and FIRP2.

Variables		FIRP2 (likelihood of farm related injury occurrence to family members while working and living on farm)						Stats
		Low (215, 51.6%)		Neutral (37, 8.9%)		High (165, 39.6%)		
		n	%	*n*	%	*n*	%	Test
Background variables	**Year of study**							
	First stage (191, 45.8%)	94	49.2	21	11	76	39.8	2.16
	Second stage (226, 54.2%)	121	53.5	16	7.1	89	39.4	
	Gender							
	Male (195, 46.8%)	101	51.8	19	9.7	75	38.5	0.43
	Female (222, 53.2%)	114	51.4	18	8.1	90	40.5	
	Farming experience							
	A great deal (222, 53.2%)	106	47.7	24	10.8	92	41.4	12.18
	Quite a bit (80, 19.2%)	40	50	6	7.5	34	42.5	
	Some (46, 11%)	25	54.3	4	8.7	17	37	
	A little (35, 8.4%)	23	65.7	2	5.7	10	28.6	
	None (34, 8.2%)	17	50	1	2.9	16	47.1	
Social influences	**a. Family/friends**							
	Yes (140, 33.6%)	93	66.42	17	12.1	30	21.43	6.48**
	No (277, 66.4%)	146	52.7	20	7.2	111	40.1	
	b. Farmers							
	Yes (161, 38.6%)	112	69.6	8	5.0	41	25.5	
	No (256, 61.4%)	103	40.2	29	11.3	124	48.4	34.18***
	c. Advisors/lecturers							
	Yes (57, 13.7%)	28	49.12	3	5.3	26	45.6	2.3
	No (360, 86.3%)	203	56.4	28	7.8	129	35.8	
Experience	**Near miss/close call**							
	Yes (106, 25.4%)	9	8.5	1	0.9	96	90.6	149.4***
	No (311, 74.6%)	206	66.2	36	11.6	69	22.2	
	Severe injury							
	Yes (58, 13.9%)	1	0	0.0	0.0	57	98.3	97.11***
	No (359, 86.1%)	214	59.6	37	10.3	108	30.1	
Awareness	**Someone who injured**							
	Yes (235, 56.4%)	90	38.3	17	7.2	128	54.5	50.20***
	No (182, 43.6%)	125	68.7	20	11	37	20.3	
	Someone who died							
	Yes (144, 34.5%)	20	13.9	9	6.3	115	79.9	152.5***
	No (273, 65.5%)	195	71.4	28	10.3	50	18.3	

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

specific risk perception. This contrasts with having a close call which has a more variable impact on, particularly, specific risk perception.

3.2.5. Awareness of fatal and non-fatal incidents

The data establishes that 235 (56.4%) students know of someone who experienced a severe farm incident whilst 144 (34.5%) know of someone who was killed as a consequence of a fatal farm incident. In both instances, awareness of fatal and non-fatal incidents positively, and significantly, impacts on all FIRPs leading us to accept H3. Students who know someone who was severely injured or killed are more risk averse compared to others ($P = 0.001$). Accordingly, awareness of fatal incidents and farm-related injuries are clearly associated with the level of FIRPs (Tables 1–4).

TABLE 3 Chi-square analysis between background and explanatory variables and FIRP3.

Variables		FIRP3 (likelihood of farm related injury occurrence whilst working with farm machinery, e.g., tractor, harvesting machines, quad etc.)						Stats
		Low (218, 52.3%)		Neutral (25, 6%)		High (174, 91.7%)		
		n	%	*n*	%	*n*	%	Test
Background variables	**Year of study**							
	First stage (191, 45.8%)	97	50.8	14	7.3	80	41.9	1.19
	Second stage (226, 54.2%)	121	53.5	11	4.9	94	41.6	
	Gender							
	Male (195, 46.8%)	111	56.9	10	5.1	74	37.9	0.29
	Female (222, 53.2%)	123	55.4	14	6.3	85	38.3	
	Farming experience							
	A great deal (222, 53.2%)	127	57.2	7	3.15	88	39.6	12.18
	Quite a bit (80, 19.2%)	41	51.2	5	6.3	34	42.5	
	Some (46, 11%)	28	60.9	3	6.5	15	32.6	
	A little (35, 8.4%)	23	65.7	2	5.7	10	28.6	
	None (34, 8.2%)	15	44.1	0	0	19	55.9	
Social influences	**a. Family/friends**							
	Yes (140, 33.6%)	90	64.3	11	7.9	39	27.9	9.95**
	No (277, 66.4%)	144	52	13	4.7	120	43.3	
	b. Farmers							
	Yes (161, 38.6%)	106	65.8	13	8.1	42	26.1	16.22**
	No (256, 61.4%)	100	39.1	22	8.6	134	52.3	
	c. Advisors/lecturers							
	Yes (57, 13.7%)	23	40.4	6	10.5	28	49.1	1.36
	No (360, 86.3%)	221	61.4	23	6.4	116	32.2	
Experience	**Near miss/close call**							
	Yes (106, 25.4%)	9	8.5	2	1.9	95	90.6	131.03***
	No (311, 74.6%)	197	63.3	33	10.6	81	22.2	
	Severe injury							
	Yes (58, 13.9%)	1	1.7	0.0	0.0	57	98.3	97.11**
	No (359, 86.1%)	205	57.1	3	9.7	119	33.1	
Awareness	**Someone who injured**							
	Yes (235, 56.4%)	82	34.9	18	7.7	135	57.4	52.92**
	No (182, 43.6%)	124	68.1	17	9.3	41	22.5	
	Someone who died							
	Yes (144, 34.5%)	21	14.6	11	7.6	112	77.8	141.2***
	No (273, 65.5%)	200	73.3	13	4.8	60	22.0	

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

3.3. OLR analysis

To further examine the study hypotheses four OLRs were developed to estimate the causal effects of social influences of "family/friends" and "farmers," the experience of a "near miss/close call" and "severe injury," and awareness of "fatal farm incidents" and "farm injury incidents" on each FIRP. Variables describing "general farming experience" and social influences of "advisors/lecturer," which were not statistically significantly associated with the four dimensions of FIRP, were excluded from the models. The goodness of fit index (chi-square) for each model was found to be statistically significant ($P = 0.001$) indicating four models fits this set of data (63). The Nagelkerke R^2 value of the four models explained, respectively, 51%, 59%,

TABLE 4 Chi-square analysis between background and explanatory variables and FIRP4.

Variables		FIRP4 (likelihood of farm related injury occurrence while working with livestock)						Stats
		Low (206, 49.4%)		Neutral (35, 8.4%)		High (176, 42.2%)		
		n	%	*n*	%	*n*	%	Test
Background variables	**Year of study**							
	First stage (191, 45.8%)	94	48.2	18	9.2	83	42.6	2.05
	Second stage (226, 54.2%)	112	50.5	17	7.7	93	41.9	
	Gender							
	Male (195, 46.8%)	111	56.9	10	5.1	74	37.9	0.42
	Female (222, 53.2%)	123	55.4	14	6.3	85	38.3	
	Farming experience							
	A great deal (222, 53.2%)	103	46.4	21	9.5	98	44.1	11.49
	Quite a bit (80, 19.2%)	39	48.8	6	7.5	35	43.8	
	Some (46, 11%)	28	60.9	3	6.5	15	32.6	
	A little (35, 8.4%)	24	68.6	2	9	9	25.7	
	None (34, 8.2%)	12	35.3	3	8.8	19	55.9	
Social influences	**a. Family/friends**							
	Yes (140, 33.6%)	85	60.71	10	7.14	45	32.14	18.35***
	No (277, 66.4%)	138	49.8	22	7.9	117	42.2	
	b. Farmers							
	Yes (161, 38.6%)	106	65.8	13	8.1	42	26.1	30.52***
	No (256, 61.4%)	100	39.1	22	8.6	134	52.3	
	c. Advisors/lecturers							
	Yes (57, 13.7%)	31	54.4	6	10.5	20	35.1	1.23
	No (360, 86.3%)	221	61.4	23	6.4	116	32.2	
Experience	**Near miss/close call**							
	Yes (106, 25.4%)	22	20.8	1	0.9	83	78.3	97.54***
	No (311, 74.6%)	212	68.2	23	7.4	76	24.4	
	Severe injury							
	Yes (58, 13.9%)	1	1.7	0.0	0.0	57	98.3	61.62***
	No (359, 86.1%)	205	57.1	3	9.7	119	33.1	
Awareness	**Someone who injured**							
	Yes (235, 56.4%)	100	42.6	15	6.4	120	51.1	41.64***
	No (182, 43.6%)	134	73.6	9	4.9	39	21.4	
	Someone who died							
	Yes (144, 34.5%)	34	23.6	11	7.6	99	68.8	138.3***
	No (273, 65.5%)	188	68.9	26	9.5	59	21.6	

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

56%, and 53% of the total variation associated with each FIRP (Table 5).

Having previously established that experience of a near miss/close call positively and significantly influences the level of FIRPs (H1b), the OLR analysis provides an estimate of the effect. The largest effects are associated with perception of risk to self, FIRP1 [Odd Ratio (OR): 2.61, $P = 0.001$], and others, FIRP2 (OR: 2.66, $P = 0.001$). Slightly smaller effects are associated with livestock, FIRP4 (OR: 2.43, $P = 0.001$), and tractor or machinery risks, FIRP3 (OR: 2.26, $P = 0.001$) (Table 5). Overall we find that students with such experience are roughly two and half times more likely to perceive a "*high*" level of FIRP. This compares to students without this

TABLE 5 Ordinal Logistic Regression analysis between explanatory variables and FIRPs.

Independent variables		Multivariate model 1, FIRP1		Multivariate model 2, FIRP2		Multivariate model 3, FIRP3		Multivariate model 4, FIRP4	
		OR[a]	95%CI[b]	OR[a]	95%CI[b]	OR[a]	95%CI[b]	OR[a]	95%CI[b]
Social influences	**Family/friends**								
	Yes	−0.89*	(−1.2) to (−0.15)	−0.57*	(−1.28) to (0.14)	−0.93**	(−1.66) to (−0.2)	−0.81**	(−1.52) to (−0.1)
	No	(Indicator variable)		(Indicator variable)		(Indicator variable)		(Indicator variable)	
	Farmers								
	Yes	−1.68***	(−1.88) to (−0.44)	−1.17**	(−1.9) to (0.46)	−1.37**	(−1.88) to (−0.46)	−1.34**	(−2.04) to (−0.66)
	No	(Indicator variable)		(Indicator variable)		(Indicator variable)		(Indicator variable)	
Experience	**Near miss/close call**								
	Yes	2.61***	(1.86) to (3.36)	2.66***	(1.9) to (3.4)	2.43***	(1.69) to (3.17)	2.26***	(1.53) to (2.99)
	No	(Indicator variable)		(Indicator variable)		(Indicator variable)		(Indicator variable)	
	Severe injury								
	Yes	2.93***	(0.86) to (4.9)	2.74***	(0.68) to (4.8)	2.75***	(0.7) to (4.8)	2.72***	(0.66) to (4.7)
	No	(Indicator variable)		(Indicator variable)		(Indicator variable)		(Indicator variable)	
Awareness	**Knowing someone who injured**								
	Yes	0.53*	(0.0) to (1.05)	0.45*	(−0.07) to (0.98)	0.48*	(0.47) to (1.51)	0.56**	(0.05) to (1.07)
	No	(Indicator variable)		(Indicator variable)		(Indicator variable)		(Indicator variable)	
	Knowing someone who died								
	Yes	1.81**	(1.23) to (2.38)	1.98***	(1.41) to (2.57)	1.69***	(1.11) to (2.26)	1.89***	(1.32) to (2.47)
	No	(Indicator variable)		(Indicator variable)		(Indicator variable)		(Indicator variable)	
	Chi-square (final)	173.191***		384.325***		261.04***		265.15***	
	Pseudo R-square								
	Nagelkerke	0.51		0.59		0.56		0.53	

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
[a]Odd Ratio.
[b]Confidence interval at 95%.

experience who are more likely to perceive a "*low*" level of FIRP across each of the measures.

Experience of a severe injury in the past year was also shown to positively impact on FIRPs (H1c). Applying OLR we estimate that this cohort of young farmers (58, 13.9%) are almost three times more likely to perceive higher FIRP1 (OR: 2.93, $P = 0.034$), FIRP2 (OR: 2.74, $P = 0.008$), FIRP3 (OR: 2.75, $P = 0.005$), and FIRP4 (OR: 2.72, $P = 0.009$) compared to their counterparts who do not have this experience. Comparing the odd ratios estimated for the experience of "*near miss/close call*" with experiencing a "*severe injury*" it is clear that the latter has a greater impact on risk perception (Table 5, Figure 2).

In contrast with the positive influences of "*experience*," social influences of family/friends or farmers (H2a) were identified as negative factors influencing the FIRPs. Regarding the social impacts of "*family/friend*," we found that students who identified this cohort as the key social referent regarding farm safety issues are more likely to underestimate FIRP1 (OR: −0.89, $P = 0.001$), FIRP2 (OR: −0.57, $P = 0.02$), FIRP3 (OR: −0.93 2.72, $P = 0.01$), and FIRP4 (OR: −0.81, $P < 0.009$) and, consequently, are more "*risk optimistic*" (Table 5). Similar to family/friends, the social influences of "*farmers*" as the main "*important others*" is a negative factor which significantly affects FIRP1 (OR: −1.68, $P = 0.001$), FIRP2 (OR: −1.17, $P = 0.001$), FIRP3 (OR: −1.37, $P = 0.001$), and FIRP4 (OR: −1.34, $P = 0.001$). It is evident from these data that the negative influence of "*farmers*" is substantially higher than "*family/friends*."

Awareness of "*fatal*" and "*non-fatal*" incidents on FIRPs (H3) was found to impact all FIRPs. The OLR analysis estimated the level for those who knew of someone who was injured to be slightly positive; FIRP1 (OR: 0.53, $P = 0.012$), FIRP2 (OR: 0.45, $P = 0.023$), FIRP3 (OR: 0.48, $P = 0.018$), and FIRP4 (OR: 0.56, $P = 0.031$) (Table 5). Knowing someone who died in a farm-fatal incident had a much greater effect and positively influences the level of FIRPs (Table 5). The risk perception of students who knew someone who died in a farm incident was over 1.6 higher than that of their counterparts without this knowledge, i.e., FIRP1 (OR: 1.81, $P = 0.001$), FIRP2 (OR: 1.98, $P = <0.006$), FIRP3 (OR: 1.69, $P = 0.003$), FIRP4 (OR: 1.89, $P = 0.001$).

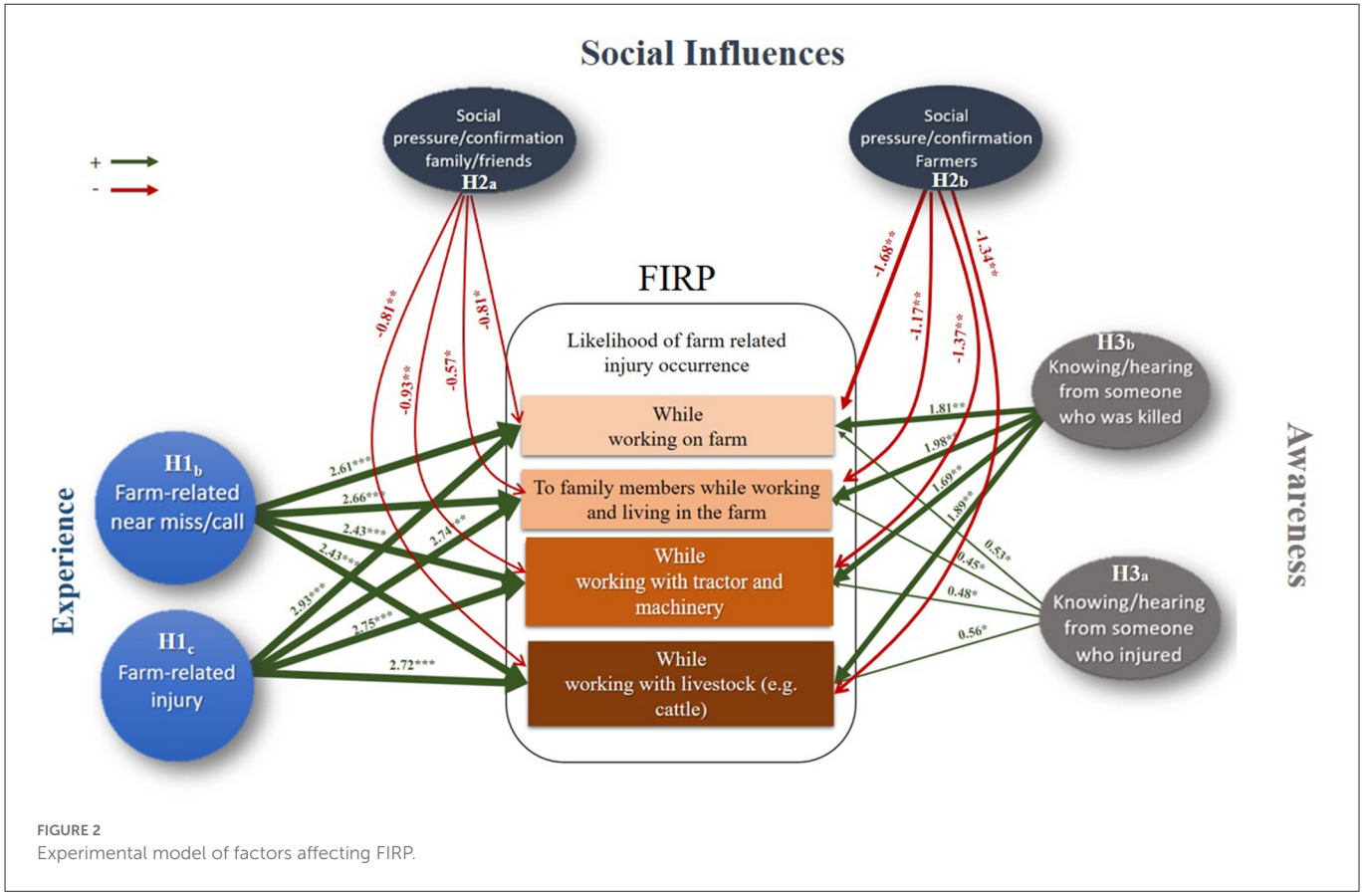

FIGURE 2
Experimental model of factors affecting FIRP.

4. Discussion

In answer to the overarching question that guides this paper, we found that experience, social influences, and awareness do matter when it comes to shaping young farmers' risk perception. Worryingly but not surprisingly, the analysis leads us to accept H2b, i.e., that social influences of, particularly "*farmers*," were identified as having the largest and most negative effect on FIRPs. More positively, our experimental model (Figure 2), identifies experiences that increased FIRP, i.e. having a near miss or close call (H1b), experiencing a severe injury (H1c), and knowledge of someone who died in a farm incident (H3b) all have positive effects on risk perception. We provide a summary of these findings in Table 6.

Accordingly, we conclude that the main reason almost half of the students who participated in this study are "*risk optimistic*" is explained by the fact that they are highly affected by "*farmers*" as key "important others," and have not experienced a near miss or close call in the past year (Figure 3). This cohort are also less likely to know someone who died in a farm-related incident. The combination of negative social influences of "*family/friends*" on FIRPs along with the lower level of awareness of farm-related incidents contribute to lower FIRPs. When taken in combination, this contributes to their "*optimistic*" perception of risks (Figure 3).

Our findings are in line with the extant research that highlight many younger farmers tend to be "*risk optimistic*" and, consequently, underestimate the risks to themselves and others associated with farming activities (3, 9, 38, 47, 65). Our study showed that over half of the students perceive a lower chance of injury occurrence

TABLE 6 Summary of hypothesis tests.

Hypothesis	Result
H1a: Farming experience is positively associated with higher levels of FIRP among young farmers.	Rejected
H1b: The experience of a near miss or close call will positively affect FIRP among young farmers	Accepted
H1c: The experience of a severe farm-related injury will positively affect FIRP among young farmers	Accepted
H2a: Social influences from (a) family/friends and (b) farmers will negatively affect FIRP among young farmers	Accepted
H2b: Social influences from (c) lectures/advisors will positively affect FIRP among young farmers	Rejected
H3: Knowing someone who was: (a) injured; or (b) killed, resulting from a farm-related incident positively affects FIRP among young farmers	Accepted

while working on the farm, with tractor/farm machinery, or livestock. Furthermore, almost the same proportion of students are also "risk optimistic" concerning their family members working/living on the farm. This finding underlines the crucial need for targeting this cohort and improving FIRP through formal education which fosters the development of a "safety mindset" among this cohort as part of the National Safety Plan 2021–2024 (66). To this end, there is a need for tailored educational tools/programs to be embedded in academic education that enhance FIRPs.

Interestingly, our findings show that despite a large group of "*risk optimistic*" students, there is another cohort of students who are "*risk-averse*" and more likely to avoid taking risky actions. This

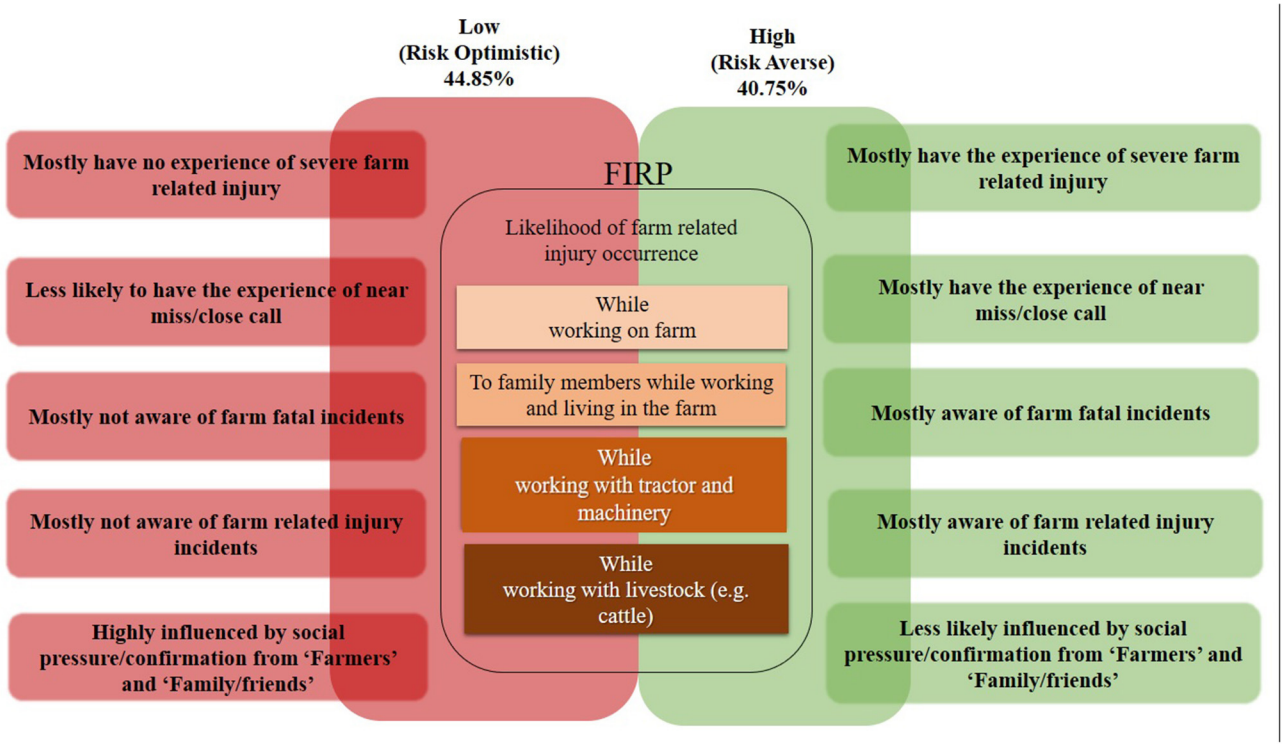

FIGURE 3
The role of experience, awareness, and social influences on FIRPs.

finding is in line with a number of studies which report young farmers may perceive higher levels of risk despite social pressure from their parents (36, 37, 40, 49). Furthermore, comparing the background variables of two cohorts, the study findings illustrate that both "*risk optimistic*" and "*risk averse*" students are almost the same in age, gender proportion, stage of education and, more importantly, general farming experience. Therefore, unlike previous studies that mentioned age, gender and farming experience as significant factors contributing to FIRP (4, 36, 39, 41, 49, 53, 65), we found these factors are not significant in determining whether students are "*risk optimistic*" or "*risk averse*". Given this finding, it prompts the question of "what leads students with similar socio-demographic characteristics be "*risk optimistic*" and, more importantly, what might influence them to be "*risk averse*"?"

The OLR analysis answers this question and establishes that students form their estimation of the risk of injury occurrence, to themselves or others, based on personal experience of severe injury or a near miss / close call. This finding aligns with studies that found farmers who experienced severe farm injury to be more "*risk-averse*" and less likely to engage in risky actions (4, 9, 28, 43, 47). Young farmers are, however, less likely to be severely injured (16, 32–34); in this study 14% of students reported such incidents. As a consequence, the impact of direct experience is limited with this particular cohort and, consequently, it shows that the majority of young farmers are "*risk optimistic*."

These findings highlight that students are primarily reactive in terms of shaping their FIRP, i.e., they may enhance FIRPs only after they have experienced a severe injury. In support of this conclusion, we found that, 25% of the students who participated in this study reported their FIRPs being strongly, and positively, affected by a close call or near miss. These results reflect the published literature that highlights that younger farmers mostly experience near misses, close calls or minor injuries (16, 32–34) and adds to this body of work by demonstrating that such experiences result in a positive impact on risk perception, both general and specific. The question then is how to apply this knowledge, i.e. how to provide young farmers with the capacity to assess risk in order to enhance FIRP without them having to experience a severe injury, close call or near miss.

Despite supporting H2c, We found that "farm advisors/university lecturers" have a limited impact on young farmer's FIRP. Whilst the provision of basic knowledge regarding risks and risk assessment are important elements of farm safety education and training, our findings demonstrate that social influences play a stronger role in shaping risk perception. This reflects a growing body of literature that highlights risk-taking behaviors are socially accepted and an established part of farming cultures (13, 14, 19, 20, 49). The findings presented in this paper are in line with a number of studies that found young farmers accrue cultural capital as "authentic farmers" with "important others" by modeling their behaviors on those of older or more experienced farmers (67). It is important to note that this behavior also applies to women and consideration should be given to exploring the underlying motivations of risky behaviors as part of farm safety education or training courses (19). The research presented in this paper highlights the negative influence that "farmers," in particular, and "family/friends" have on FIRP. The (partial) answer to the question posed at the end of the previous paragraph is to implement blended approaches to learning that simulating the consequences of being "*risk optimistic*." This can be achieved by

incorporating experience sharing of close calls/near misses between young farmers (13, 31), inclusion of survivor testimonials from "leading farmers" within modules or courses (36, 44), inclusion of safety topics within farm visits and group and individual assessment of incident cases using established occupational safety approaches, e.g., Fault Tree Analysis. Education tools should reflect real-life experiences and make tangible the consequences of risky practices or actions for young farmers rather than only focusing on identification of dangers and risks. By grounding educational approaches in practice and moderating the negative impact of existing farming culture *via* social influences of "key important others" it is possible to challenge the social values/norms within farm households and farming communities. This, in turn, can contribute to the reshaping of farm safety culture where being "*risk averse*" is socially valued and preventing risks is deemed to be what a good farmer is expected to do.

5. Limitations

Key limitations associated with this research related to the sourcing of the sample from one university in Ireland. UCD has the largest intake of undergraduate students studying agriculture of all the third level education institutions in Ireland. This is a diverse population drawn from all parts of Ireland and includes those from larger, more intensive farm systems where safety incidents are more common and those from smaller or extensive farms. As a consequence of targeting the population of first and second year students, there is insufficient variation in the ages of respondents, ranging 18–20, to test the effect of age on each of the hypotheses developed in this paper. This highlights the need for further research with a broader population, including those in high school or who have recently completed their education and those who are not students but who work/live on farms. Such research would give a better understanding of whether FIRP changes with age and the extent to which the effect of social influences changes with age.

The result that there is a sizable group that are risk optimistic points to the need for additional research to explore the basis for such optimism and associated attitudes and behaviors. The lower levels of experiencing an accident (or at least admitting to it) and awareness of injuries or fatalities may reflects a culture denial, i.e. of not talking about these events. This suggests a need for further research to assess if some students are more open to reporting personal experiences. Equally, research is required to understand whether there are students that are averse to discussing experience of injuries or experience of fatalities. The inclusion of attitudinal questions would be useful in measuring willingness to discuss/report farm safety issues.

Due to the nature of the cross-sectional studies, there are a number of limitations regarding the results, particularly the fact they provide a snapshot of a particular point in time and difficulties in making causal inferences. We sought to overcome the latter limitation by recruiting a large sample population who were, in terms of age, relatively homogeneous. This limits some of the variation that would, otherwise, influence the results. In terms of the snapshot effect, this points to the need for a longitudinal study which would have the benefit of assessing changes in FIRP over time, i.e., measuring if there is a waning in the influence of experience of an injury or knowledge of injuries and death.

Finally, whilst most farms in Ireland can be classified as family farms, i.e., owned and largely operated using family labor and, consequently, are reflective of many farms in other jurisdictions, they have a particular socio-ecological context that may differ substantially compared to other countries.

6. Conclusion

This study supports the design and development of FHS modules for young farmers by identifying the key determinants of FIRPs in countries with family farms. According to the findings, to achieve a "safety mindset" among this cohort, the academic institutions should design specific FHS modules underpinned by a community-based co-design approach. This approach can inform curriculum design, education tools, and delivery. This study argues that knowledge exchange and sharing amongst students of first-hand experiences of close calls, near misses, or severe injury and involving guests who are willing to share stories of those who were injured/died in farm incidents will positively impact students' FIRPs. This is important as many young farmers are highly negatively influenced by farmers and family/friends resulting in them underestimating the risks associated with farming. This paper shows that there is a valuable source of knowledge amongst young farmers who have experienced an injury, near miss/call or know someone who died or was injured. This presents an opportunity to include peer knowledge and experiences, provide insights into the context to the incident and show how it has influenced their approach to safety. In developing these approaches there is a requirement to take into consideration the ethical implications and potential consequences of asking young people to publically share knowledge or experiences of traumatic events.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author (david.meredith@teagasc.ie).

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MM and DM developed the conceptual framework and associated research questions addressed in the paper and drafted the questionnaire whilst JM and SF provided expert input to the wording of questions and response options. JM organized the collection of pilot data which were analyzed by MM. SF organized collection of the survey data which were analyzed by MM. MM prepared the initial draft of this manuscript. JM, SF, and JK reviewed the paper prior to submission and provided additional input to the discussion and recommendations. MM and DM reviewed and edited

the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Mental health of agricultural adolescents and adults: Preliminary results of a five-year study

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Background: Work-related stressors common to agriculture have been associated with adverse mental health outcomes among adult farmers and ranchers. However, the mental health status of agricultural youth is unknown, despite farm and ranch youth being exposed to the same occupational hazards as their adult counterparts. The objective of this study was to estimate the prevalence of symptoms of depression and anxiety among farm adults and their adolescent child and examine the correlation between symptoms of mental health conditions and financial indicators described in the Family Stress Model (FSM).

Methods: Farm families were recruited to participate in online surveys by mail, email, and social media. One adolescent and at least one adult from each family were invited to complete on online survey. Where available, validated instruments were used to collect mental health, stress, family dynamics, and household financial variables. Descriptive statistics were used to describe sample demographics and prevalence of symptoms of depression and anxiety. Pearson correlations describe associations between variables within the Family Stress Model.

Results: Farm families ($N = 122$) completed the online survey. The mean age of farm parents was 41.4 years (SD = 4.4) and the mean age of farm adolescents was 15.4 (1.2). A majority of farm parents and farm adolescents were male, 58.2% and 70.5%, respectively. The sample was primarily white, non-Hispanic. In this sample of farm parents and adolescents alike, 60% met the criteria for at least mild depression, based on the Patient Health Questionnaire-9 (PHQ-9) and Patient Health Questionnaire-A (PHQ-A). Similarly, among adolescents, 45.1% met the criteria for Generalized Anxiety Disorder (GAD), as did 54.9% of adults. As a measure of economic hardship, per capita income by itself showed relatively low correlations, even with other economic measures ($r = 0.11$ with negative financial events, $r = 0.20$ with financial needs, $r = 0.17$ with financial situation, and $r = 0.27$ with debt). Parent depressed mood was in turn highly associated with adolescent depression ($r = 0.83$), social anxiety ($r = 0.54$), and generalized anxiety ($r = 0.69$).

Conclusions: The results show a strong association between parent and adolescent mental health and parental depressed mood and debt. There is not a clear association between economic stress and mental health in this sample, but further work is needed to be done at a population level. Preliminary results are promising for application of the full Family Stress Model as we continue to accrue farm families into the study cohort.

KEYWORDS

agriculture, adolescent, mental health, stress, depression

1. Introduction

In the United States, sectors of the agricultural industry have been experiencing economic downturn in the last decade (1). Among farmers, personal finances, economics, and fluctuating commodity prices are consistently cited as sources of stress. In addition to financial factors, interpersonal relationships, farm succession, and unpredictable and unreliable environmental conditions, such as natural disasters and drought, also contribute to producers' stress (2–5). Chronic stress has been associated with a myriad of mental health outcomes such as anxiety, depression, and substance use. The prevalence of common mental health conditions, specifically anxiety and depression, is consistently higher among adult farmers than the general population (5–7).

The mental health of agricultural producers and workers has become a national priority. Cooperative Extension Services, United States Department of Agriculture (USDA), state departments of agriculture, non-profits, and health and safety professionals have organized efforts to address the growing concern. Research has estimated the prevalence of mental health conditions among the population and sub-populations (3, 5, 6, 8, 9). Mental health literacy programs have been developed and evaluated to increase self-efficacy among non-mental health professionals to respond to crises in rural and farm communities (10). Mental health providers have partnered with commodity groups and agricultural organizations to offer low or no-cost behavioral health services to agricultural (11). However, research, resources, and services have largely focused on adult agricultural producers.

Agriculture is a unique occupational industry. A majority of agricultural work occurs on private, independently owned and operated farms and ranches, which often also serve as a residence for children (1). As such, adolescents and children are often present in the agricultural environment, and in some instances, participating in agricultural work. Consequently, youth are exposed to the same work-related hazards of their adult counterparts, such as machinery and livestock.

Agricultural work contributes to injuries and illnesses among youth. There is a growing number of epidemiologic studies of injuries to farm children which describe risk factors, medical outcomes, and injury agents (12, 13). As a result, interventions have been evaluated and policies recommended to prevent child agricultural injuries (14–18). Similarly, there are recognized hazards in the agricultural environment, such as chemicals, gases, extreme climate conditions, physical hazards including noise, and zoonotic diseases which threaten the health of agricultural youth. While the work-related stressors and associated mental health outcomes among adult farmers are well-documented (5–7), and injuries to children well-examined (12, 13), the mental health of farm adolescents is unknown.

The main objective of this five-year project is to examine the relationships between work-related stress, family disruption, and mental health of farm adolescents and their farm parents by examining associations and relationships within the Family Stress Model (FSM). In this analysis, we describe the study population and identify the prevalence of positive screens for common mental health conditions among farm adolescents and adults and look for correlations between variables of the Family Stress Model. Data for this analysis was collected in summer, 2021.

1.1. Family Stress Model

The Family Stress Model suggests specific processes through which economic hardship is expected to impact adolescent development by way of family disruptions, relationships, and parenting. The FSM was originally conceptualized by Conger et al., who tested the adequacy of the model on a sample of Midwest, US, farm, and rural families experiencing economic hardship during what would come to be known as the 1980's Farm Crisis (19). Results supported the central hypothesis that coercive family processes may link family economic stress to problematic child and adolescent development (19).

The FSM [A schematic of the Family Stress Model can be found in Conger et al. (20)] suggests that economic hardship, characterized by negative economic events and coupled with low family income, increase the economic pressure experienced by parents. Negative economic events include a myriad of situations including job-loss, home foreclosure, forced sale of land, and alike. Economic pressure reflects the realities of economic hardships and include cutback on essential goods and services, daily expenditures, and forgoing bills. The FSM proposes economic pressure will increase emotional distress among parents, including symptoms of psychological distress, which will then disrupt the functioning of their relationship and intensify conflict in the relationship. Inter-parental conflict then disrupts effective parenting and strains the child–parent relationship and poor parenting will predict child emotional and behavioral problems (19–21). The FSM has been applied to various populations to examine the relationship between economic pressure, parental emotional and behavioral problems, and adolescent externalizing and internalizing behaviors (19–23).

2. Materials and methods

2.1. Study design

This cross-sectional study was conducted among agricultural producers and their adolescent children from June to August 2021 in the US.

2.2. Target population

The target population was farm adolescents between the ages of 13 and 18 years old and their parents residing on farms in the U.S. Five study states (Illinois, Iowa, Wisconsin, Minnesota, and Iowa) were selected because they are among the most agriculturally productive in the U.S., have a high proportion of primary producers that report farming as their full-time operation, and a high proportion of primary operators that reside on the farm they operate (24). However, during recruitment the target population was expanded to include farm and ranch families from the U.S.

2.3. Recruitment

Two primary strategies were employed to recruit farm families into the study.

2.3.1. Agricultural producers list

A list of addresses of 1,000 agricultural producers in seven Midwestern states with at least one adolescent in the household was purchased from Farm Market iD (FMiD). FMiD maintains a list of farm owners and operators based on the same sources as the U.S. Department of Agriculture's (USDA) databases and estimates 95% coverage of farm owners and operators. FMiD overlayed USDA agricultural census variables with consumer variables to identify primary producers who work on a farm full-time, live on the same farm they operate, and have at least one adolescent (aged 13–17) in their household (25).

Recruitment and survey materials were mailed to the 1,000 agricultural producers using a modified Dillman approach to encourage survey response (26). Dillman encourages unique, repeated contacts with potential participants (26). An introductory postcard to pique interest was sent to each address. Three weeks later, a packet of information followed which included the objectives of the study, IRB information, directions for participating, and a QR code to the online surveys. Three weeks later, a reminder postcard was sent which included the QR code to the online surveys.

2.3.2. Online study blog

Recruitment also occurred online. The project team partnered with Extension, commodity groups, and farm organizations to disseminate information about the study via email, newsletters, and social media. Emails, newsletters, and social media posts directed individuals to an online study blog that described the objectives of the study, provided IRB information, directions for participating, and a link to the online surveys. Two, duplicate online surveys, with unique web addresses, were created to distinguish participants by recruitment method.

2.4. Procedures

The project team worked with the Research Electronic Data Capture (REDCap) administrators at the University of Illinois Urbana-Champaign to develop a series of consent forms and assent forms in addition to the online surveys, to ensure protection of participants. REDCap is a secure, web-based application designed to support data capture for research studies, providing: (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources (27).

A QR code and link on the study blog, provided on recruitment materials (letters, emails, social media posts), led to an adult/parent consent form. The consent form collected name, email address, and signature of an adult/parent (P1). The form also consented an adolescent in the household to participate and collected the name and email address of the consented adolescent. Finally, the form inquired about a second adult in the household and asked for the name and email of the second adult (P2), if applicable. After consenting themselves, consenting the adolescent in the house, and providing the contact information for a second adult (if applicable and optional) the adult proceeded to the P1 online survey. REDCap auto emailed the adolescent a link to the assent form, which had to be completed by the adolescent prior to unlocking the adolescent survey. Similarly, REDCap auto-emailed the second adult in the household a link to their consent form and ultimately their online survey, the P2 survey. REDCap linked family consent forms, assent forms, and surveys. All survey participants were emailed an electronic Amazon gift card valued at $10.

2.5. Materials

Online surveys were used to collect information about farm economics, family dynamics, and mental health from farm parents and adolescents. Here, we report on all survey sections; however, not all are described in the results or discussion as sample size precluded statistical modeling of FSM constructs.

2.5.1. Adult survey

The Farm Stress and Mental Health Adult Survey was completed by P1 and P2, if applicable. The adult survey took a median of 19 min to complete and could be completed on a smartphone, tablet, or computer. The adult survey included the following sections and questions and/or instruments.

2.5.1.1. Screening

Adults were asked whether they identify as a (1) primary operator or principal operator of a farm, ranch, or agricultural operation, (2) partner or spouse of the primary operator or principal operator of a farm, ranch, or agricultural operation, or (3) none of the above. Adults were asked whether they reside, at least 50% of the time, on the farm, ranch, or agricultural operation. In order to proceed to the remained of the survey, adults must have identified as either the primary operator or partner/spouse of the primary operator and reside on the farm/ranch/agricultural operation at least 50% of the time.

2.5.1.2. Demographic and farm characteristics

Adults responded to the following questions: state of residency, age, gender, ethnicity, race, education, material status, number of children had, age range of children, number of children in the household, military status, employment status, number of years farming, primary farm commodity, secondary farm commodity, annual farm/ranch net sales, and residential environment.

2.5.1.3. Health

Adults responded to the following questions about their health: diagnosis of chronic health conditions (asthma, arthritis, anxiety, caner, COPD, dementia and/or Alzheimer's Disease, depression, diabetes, hearing loss, heart condition, high blood pressure, high

cholesterol), weight, height, and average number of hours of sleep each night.

2.5.1.4. Mental health

The Generalized Anxiety Disorder-7 item scale (GAD-7) was employed to identify self-reported symptoms of anxiety among adults. This seven-item questionnaire has been widely used in population-based survey studies (28) and among farm populations (5, 29) and has high internal validity ($a = 0.81$), sensitivity (89%), and specificity (82%) (28). Participants responded to seven unique statements that queried the frequency of anxiety-related symptoms as experienced in the past 2 weeks (e.g., *not being able to stop or control worrying*). Response options were; not at all, several days, over half the days, nearly every day. Response options were assigned a point-value; not at all = 0, several days = 1, over half the days = 2, nearly every day = 3. The response option point-values for each of the seven unique anxiety-related symptoms were totaled for an individual's total score. The possible score range is 0–21. Scores of 5–9 indicate mild anxiety, 10–14 moderate anxiety, and 15–21 severe anxiety (28).

The Patient Health Questionnaire-9 (PHQ-9) identified self-reported symptoms of depression. The nine-item questionnaire has been used to estimate the prevalence of depression among the general U.S. population (30) and farmers (5, 29) and demonstrates high internal validity ($a = 0.91$), sensitivity (88%), and specificity (89%) (Kroenke et al., 2001). Participants responded to the nine statements that inquire about the frequency of depressive symptoms as experienced in the past 2 weeks (i.e., poor appetite or overeating, feeling tired, or having little energy). Response options are; not at all, several days, over half the days, nearly every day. Each response option is assigned a point-value; not at all = 0, several days = 1, over half the days = 2, nearly every day = 3. The response option point-values for each of the seven unique depression-related symptoms are totaled for an individual's total PHQ-9 score. The possible score range is 0–27. Cut off points are: 0–4 is considered normal range or full remission; 5–9 is considered minimal depressive symptoms; 10–14 is considered major depression, mild severity; 15–19 is considered major depression, moderate severity; and 20 or higher is considered major depression, severe severity (30).

The Coronavirus Anxiety Scale (CAS) was used to identify probable cases of dysfunctional anxiety associated with the COVID-19 crisis. The five-item scale has demonstrated solid reliability and validity (31). Adults responded to each item indicating how often they had experienced each in the past 2 weeks on a five-point Likert scale (0 = not at all, 4 = nearly every day). Individual scores were generated by summing the five response options. The permissible range for scores is 0–20 with higher scores indicating more severe anxiety (31, 32).

2.5.1.5. Interpersonal/Marital conflict

The Behavioral Affect Rating Scale (BARS) was used to assess relationship warmth and hostility among adult partners (33). Each adult responded to 22 items describing the behaviors of their partner over the past year. Adults indicated how often, on a Likert scale (1 = always, 4 = never), their partner engaged in 9 items related to warmth (affection, humor, and acted supportively) and 13 items related to hostility (shout/yell, insult). Items within each subscale (warmth and hostility) were summed. Higher scores indicate lower warmth and higher hostility. These scales have exhibited high predictive validity in prior studies (19, 22, 34).

2.5.1.6. Social support

The Multidimensional Scale of Perceived Social Support (MSPSS) measured farm parents perceived social support (35) from three sources: family, friends, and a significant other. Participants responded with how strongly they agreed to 12 statements (e.g., *there is a special person who is around when I am in need*) on a seven-point Likert scale (very strongly disagree to very strongly agree). Each response was assigned a point value for a cumulative score. Three factor group (family, friends, and significant other) scores were calculated by summing the responses to each of the four items within each group with higher scores indicating more perceived social support (35).

2.5.1.7. Parenting style

Parenting involvement and control were assessed using a modified version of the Steinberg instrument (36), a 15-item instrument that includes nine items related to involvement and six items related to control. Adults responded to each item indicating how much they agree with each item on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). A control and involvement score were calculated for each adult by summing the values of each response. Control and involvement scores were dichotomized at their median values to identify high and low control and involvement categories.

2.5.1.8. Economic hardship

Adult respondents completed three subscales adopted from the economic pressure measures developed by Conger et al. (19): (1) make ends meet, (2) material needs, and (3) cutbacks/adjustments. The first subscale included two items indicating whether parents felt that they could "make ends meet" during the past 12 months. The first item was, "During the past 12 months, how much difficulty have you had paying your bills?" and response options were a great deal of difficulty, some difficulty, a little difficulty, and no difficulty at all. The second item was, "Think again over the last 12 months, generally, at the end of the month, do you end up with…" and response options were more than enough money left over, some money left over, just enough to make ends meet, not enough to make ends meet. The second subscale measured whether the household could meet its basic material needs. Adults responded to seven basic material needs (clothing, transportation, a home, furniture and household appliances, food, and medical services). Responses were dichotomously scored (1 = yes, 0 = no) and summed to create a subscale score. The third subscale assessed whether the family had made significant financial cutbacks in several areas, including food, medical care, and utilities, because of economic hardship. Responses were dichotomously scored (1 = yes, 0 = no) and summed to create a subscale score. Each indicator was coded so that higher scores reflected greater economic pressure.

2.5.1.9. Stress

A modified Farm Stress Survey was used to identify sources of farm stress among adults. This 40-item instrument measures seven dimensions of stress (personal finances, time pressure, climate

conditions, geographic isolation, hazardous working conditions, general economic conditions, and interpersonal relationships) (37). Participants indicated the extent to which each of the items of the Farm Stress Survey was a source of worry or concern in the past 2 weeks on a five-point Likert-type scale (1 = not at all, 5 = an overwhelming extent). *Farm Stress Survey* subscale scores were calculated by determining the mean response to the items within each subscale. Permissible subscale scores range from 1 to 5 give higher scores indicating higher perceived concern.

2.5.2. Adolescent survey

The Farm Stress and Mental Health Adolescent Survey was completed by the farm adolescent. The adolescent survey took a median of 19 min to complete and could be completed on a smartphone, tablet, or computer. The adolescent survey included the following sections and questions and/or instruments.

2.5.2.1. Screening

Adolescents were asked whether they reside, at least 50% of the time, on a farm, ranch, or agricultural operation. Adolescents were also asked their age, with the following response options to choose from: 13, 14, 15, 16, 17, 18, other. In order to proceed to the remainder of the survey, adolescents must have indicated they reside on a farm, ranch, or agricultural operation at least 50% of the time and indicated they were between the ages of 13 and 18. If an adolescent indicated they were not between the ages of 13 and 18 and/or did not reside on a farm or ranch or agricultural operation at least 50% of the time they were directed to the end of the survey.

2.5.2.2. Demographics and farm characteristics

Adolescents responded to questions about age, school grade, race, state of residency, farm work status, hours per week involved in farm work during the summer and school year, farm injury experience.

2.5.2.3. Health

Adolescents responded to the following questions about their health: self-rated physical and mental health, diagnosis of chronic health conditions (asthma, arthritis, anxiety, cancer, COPD, dementia and/or Alzheimer's Disease, depression, diabetes, hearing loss, heart condition, high blood pressure, high cholesterol), weight (reported in pounds), height (recorded in feet and inches), average number of hours of sleep each night.

2.5.2.4. Mental health

The Patient Health Questionnaire-A (PHQ-A) identified self-reported symptoms of depression among adolescents. The PHQ-A is a modified PHQ-9 appropriate for adolescents and has demonstrated satisfactory sensitivity, specificity, diagnostic agreement, and overall diagnostic accuracy, compared with the clinical interview (38). Participants responded to the nine statements that inquired about the frequency of depressive symptoms in the past 2 weeks (i.e., *poor appetite or overeating*, *feeling tired or having little energy*). Response options are assigned a point-value; not at all = 0, several days = 1, over half the days = 2, nearly every day = 3. The response option point-values for each of the seven symptoms were totaled for an individual's total PHQ-A score. The possible score range is 0–27. Cut off points are: 0–4 is considered normal range or full remission; 5–9 is considered minimal depressive symptoms; 10–14 is considered major depression, mild severity; 15–19 is considered major depression, moderate severity; and 20 or higher is considered major depression, severe severity (38).

The Screen for Anxiety Related Disorders (SCARED) was used to screen farm adolescents for childhood anxiety disorders including general anxiety disorder, separation anxiety disorder, panic disorder, social anxiety, and school phobia. The SCARED consists of 41 items related to the 5 factors [general anxiety disorder (9 items), separation anxiety disorder (8 items), panic disorder (13 items), social anxiety (7 items), and school phobia (4 items)] that parallel the DSM-IV classification of anxiety disorders (39). Adolescents indicated how true each item was in the past 3 months on a three-point Likert scale (0 = not true or hardly true, 2 = very true or often true). Scores for each anxiety related disorder were calculated by summing the responses to the items within each factor. Cut-off scores indicating probable or likely anxiety vary by type of anxiety related disorder. Across all 41 items, a total score of $\geq$25 may indicate the presence of an anxiety disorder (39).

2.5.2.5. Stress

The Adolescent Stress Questionnaire (ASQ) evaluated sources of stressors among adolescents. This is a 27-item inventory reflecting five dimensions of stress [home life (7 items), school attendance and teacher interactions (11 items), peer pressures (4 items), future uncertainty (3 items), financial pressure (2 items)]. Adolescents indicated how much stress each item has caused in the past 12 months on a Likert scale (1 = not at all, 5 = very stressful). Dimension scores were calculated by summing the affirmed response to each item within each dimension (40). The ASQ has been shown to be valid for measuring stress in research and clinical contexts (40, 41).

2.5.2.6. Risk-taking behaviors

Adolescents self-reported risk-taking activities related to substance use, sexual activity, intentional/unintentional injury. Adolescents self-reported how often they participated in the following activities in the past 30 days and the past 12 months: number of times rode in a car or other vehicle driven by someone who had been drinking alcohol, seatbelt use when riding in a car driven by someone else, how many days they text or e-mail while driving a car or other vehicle, days carried a weapon, days carried a weapon on school property, days carried a gun, days skipped school, and number of times in a physical fight. Adolescents responded to whether they considered suicide, made a plan to attempt suicide, or had attempted suicide in the past 6 months (42). Adolescents indicated whether they ever tried a substance, how old they were when they first tried the substance, how many days they used the substance in the past 30 days. The following substances were inquired about: cigarettes, electronic vapor products, chewing tobacco, alcohol (includes beer, wine, wine coolers, and liquors), marijuana, synthetic marijuana, prescription medication for non-medication purposes (42).

2.5.2.7. COVID-19 experience

The COVID-19 Adolescent Symptom and Psychological Experience (CASPE) was used to identify farm youths' experience with COVID-19 (43). Adolescents responded to how much and how the COVID-19 outbreak negatively and positively impacted their daily life and how stressful the COVID-19 disruptions were. Adolescents also indicated to what extent they had felt 19 emotions (e.g., anxious, happy, worried, distressed, calm) in the past 7 days because of the COVID-19 outbreak on a five-point scale (very slightly or not at all—extremely). Adolescents indicated their level of concern about the COVID-19 outbreak on 16 circumstances or situations (i.e., having to stay home, a family member might get sick, having enough to eat) on a five-point scale (very little or not at all—a great deal). Finally, adolescents responded to six emotions (relaxed, hopeful, anxious) indicating how *much more* they experience the emotion compared to before the pandemic on a five-point scale (not at all—a great deal).

2.6. Data cleaning

Surveys for analysis were first limited to those where appropriate consents were registered and surveys were completed for one adolescent paired with at least one adult/parent participant. Various procedures were used to try to ensure that surveys for analysis were limited to eligible participants who seriously attempted to complete the instruments. It was apparent early that online recruitment had been subject to multiple cyber-attacks, including software-based, automated completion of surveys (i.e., attacks by internet robots or "bots"). This was obvious for several reasons. First, within hours of posting the survey link publicly online, there were over 520 responses, an unlikely influx. Additionally, there were series of up to 20 consecutive surveys submitted with identical entries, including identical start and stop times. As soon as the research team was aware of the issue, within 2 h of the original online post, the REDCap administrator added an attention check question to all surveys. The question asked participants to select the color red from a list of colors listed below.

After data collection was complete, a series of recommended checks were employed to identify and exclude bot-generated responses from analysis (44). A number of strategies have been recommended to identify and mitigate research fraud. Among the most effective strategies are screening email addresses, screening open-ended responses, and monitoring the time and speed of survey completion. Moderately effective strategies include checking the eligibility of IP addresses and embedding attention check questions into the survey (45). Based on these recommendations and available information, a combination of electronic processing and manual review was then used to create 11 flags for suspicious forms (described below).

First, duplicate forms were removed from the dataset. As mentioned previously, series of up to 20 consecutive surveys were submitted with identical entries, including identical start and stop times. All duplicate time entries were reviewed, and all duplicate and suspect survey series were excluded. Duplicate surveys were further identified by electronic identification of duplicate parent

TABLE 1 Demographics and health characteristics of farm parents (P1) (*N* = 122).

Demographic	*N* (%) or Mean (SD)
Age	41.4 (4.4)
Sex	
Male	71 (58.2%)
Female	51 (41.8%)
Race	
White	103 (84.4%)
Black or African American	14 (11.5)
Other	5 (4.1%)
Hispanic	27 (22.1%)
Veteran	14 (11.8%)
Education (highest level)	
High school diploma	50 (42.7%)
Associate degree	37 (31.6%)
Bachelor's degree	26 (22.2%)
Master's degree or higher	4 (3.4%)
Marital status	
Married	117 (97.5%)
Divorced/separated	3 (2.5%)
Single	0 (0.0%)
Residence	
Rural	74 (60.7%)
Suburban	45 (36.9%)
Urban	3 (2.5%)
Primary farm/ranch operator (vs. partner or spouse)	83 (68.0%)
Farm full-time (vs. part-time)	114 (95.8%)
Mean number of children	1.4 (0.6)
Median years farming	13.3 (5.8)
Median farm income (US Dollars)	120,000.00
Mean farm income (US Dollars)	277,444.00
BMI	
Underweight	16 (13.1%)
Normal	57 (46.7%)
Overweight	39 (32.0%)
Obese	6 (4.9%)
NA (could not be calculated)	4 (3.3%)
Self-rated physical health	
Excellent	38 (31.1%)
Good	62 (50.8%)
Fair	22 (18.0%)
Poor	0 (0.0%)

(Continued)

TABLE 1 (Continued)

Demographic	*N* (%) or Mean (SD)
Self-rated mental health	
Excellent	42 (34.7%)
Good	61 (50.4%)
Fair	17 (14.0%)
Poor	1 (0.8%)
Chronic health condition	
Asthma	3 (2.5%)
Arthritis	20 (16.4%)
Anxiety	20 (16.4%)
Cancer	0 (0.0%)
COPD	3 (2.5%)
Dementia	0 (0.0%)
Depression	5 (4.1%)
Diabetes	3 (2.5%)
Hearing loss	3 (2.5%)
Heart condition	2 (1.6%)
Hypertension	25 (20.5%)
High cholesterol	2 (1.6%)

or adolescent e-mail addresses, and through manual review of suspicious follow-up e-mail solicitations to the investigators.

From there, the research team employed a combination of electronic and manual processing to create a series of 11 flags to help identify suspicious survey respondents. Five flags were related to discrepancies between parent/adult and adolescent surveys and included (1) different state residency for adolescent and adult; (2) less than 15-year difference between adult and adolescent ages; (3) age of adolescent outside the range reported for youngest and oldest child; (4) inconsistent race (parents only white with adolescent only black, or the reverse); (5) Latino adolescent with both P1 and P2 not Latino. Two flags were related to improbable or incorrect responses on the surveys and included (6) failure to select "RED" on security question where instructed simply to "Pick RED" as the response; and (7) height outside CDC norms of 0.05–99.95%. Embedding attention check questions, requesting a specific response from survey participants, is a moderately effective strategy for detecting bot responses and identify risk of lower data quality, however, in time, bots can learn the correct answer to the attention check questions (44).

Additionally, based on review of completion times (median 19 min), surveys with unusually short times were also believed to be invalid or incomplete and flagged (8). Surveys completed in <8 min were excluded. Monitoring the speed of survey competition has also been recommended as a method to identify bots (45).

The last three flags were based on responses to open text responses and included (9) incoherent or inappropriate text for primary farm commodity; (10) commodity reported in singular, for example "Ostrich" or "Goose"; (11) commodities noted as associated with submissions dropped as clearly invalid (e.g., "POTATOES, TOMATOES" or "Corn, barley, oats"). In the course of these reviews, the few free-text fields on the survey were noted as particularly helpful in identifying bot-completed forms, which aligns with recommendations for best practices (44). However, the process is time-consuming. The principle investigator manually reviewed submitted text for farm commodities and "Other" responses, flagging suspicious forms for exclusion. Based on review of flag frequencies, the study team decided that all remaining surveys with two or more flags would be excluded from analysis.

2.7. Data analysis

In the final analysis cohort of 122 families (one adult parent and one adolescent), relatively few response items were missing. For example, individual items in the PHQ-9 were missed for at most 2/122 (1.6%) for the adult (P1) and for at most 3/122 (2.5%) of adolescents, while for both adult and adolescent five of the nine individual items showed no missing responses. To allow for some missed items, summary scores for each instrument were calculated whenever over half of items were completed, and the mean of completed items was used to scale the summary score to the same range as possible with no missing items.

Descriptive summaries were created to characterize the analysis cohort using standard descriptive statistics. Cronbach's alpha was calculated as a measure of internal consistency for the items in a summary score. Pearson correlations were calculated to evaluate the strength of associations among potential FSM model indicators. In this analysis, we present demographic characteristics, correlations between FSM model indicators, and mental health outcomes.

Analyses were completed using SAS® version 9.4 (SAS Institute Inc.) statistical software.

2.8. Ethical approval

All procedures performed and materials used in this study, involving human participants, were approved by the University of Illinois Urbana-Champaign Institutional Review Board.

3. Results

A total of 2,463 potential farm-family survey submissions were recorded. After flagging responses as described above and limiting analysis to observations with two or less flags, the final sample consisted of 122 family participants. For this analysis, families include responses from one adult parent (P1) and one adolescent. Among the 122 family participants, only 25 observations (20%) included responses from a second adult (P2). Therefore, responses from the second adult are not included in this analysis.

Table 1 shows the demographic and health characteristics of the 122 farm parents. The mean age of parents was 41.4 (SD = 4.4), and just over half of parents identified as men. A majority of farm parents were white (84.4%) and almost a quarter (22.1%) were Hispanic. Highest educational status was split between high school

TABLE 2 Demographics of farm adolescents ($N = 122$).

Demographic	*N* (%) or Mean (SD)
Age	15.4 (1.2)
Sex	
Male	86 (70.5%)
Female	36 (29.5%)
Race	
White	102 (83.6%)
Black or African American	14 (11.5%)
Other	
Hispanic	20 (16.5%)
Education level (current)	
7th	8 (6.6%)
8th	17 (13.9%)
9th	35 (28.7%)
10th	28 (23.0%)
11th	26 (21.3%)
12th	8 (6.6%)
Participate in agricultural work	65 (53.7%)
Mean hours of agricultural work during school year	14.0 (10.4)
Mean hours of agricultural work during non-school year	19.7 (16.2)
Operator of agricultural operation youth works on	
Parents	59 (92.2%)
Grandparents	3 (4.7%)
A neighbor, non-relative	1 (1.6%)
Other relative	1 (1.6%)
BMI	
Underweight	31 (25.4%)
Normal	67 (54.9%)
Overweight	14 (11.5%)
Obese	6 (4.9%)
NA (could not be calculated)	4 (3.3%)
Self-rated physical health	
Excellent	50 (42.0%)
Good	61 (51.3%)
Fair	8 (6.7%)
Poor	0 (0.0%)
Self-rated mental health	
Excellent	43 (35.5%)
Good	57 (47.1%)
Fair	18 (14.9%)
Poor	3 (2.5%)
Chronic health condition	
Asthma	5 (4.1%)
Arthritis	1 (0.8%)
Anxiety	23 (18.9%)
Cancer	0 (0.0%)
COPD	2 (1.6%)
Dementia	0 (0.0%)
Depression	8 (6.6%)
Diabetes	0 (0.0%)
Hearing loss	0 (0.0%)
Heart condition	0 (0.0%)
Hypertension	2 (1.6%)
High cholesterol	1 (0.8%)

diploma, associate's degree, and bachelor's degree. In total, 68.0% of adults indicated they are the primary operator on the farm/ranch and over 95% are full-time on the farm/ranch. The mean number of years farming was 13.3 (SD = 5.8), with 60.7% residing in rural areas and 36.9% residing in suburban areas.

Among adults, 81.9% self-rated their physical health as excellent or good and 85.1% self-rated their mental health as excellent or good. The most common chronic health conditions diagnosed were arthritis (16.4%), anxiety (16.4%), and hypertension (20.5%).

As shown in Table 2, the mean age of farm adolescents was 15.4 (SD = 1.2), 70.5% were male, 83.5% were white, and 11.5% were Hispanic. Adolescents' educational levels ranged from 7th to 12th grade, with nearly three-quarters between 9th and 11th grade. Over half (53.7%) indicated they participate in farm/ranch work, working an average of 14.0 (SD = 10.3) hours a week during the school year and 19.7 (SD = 16.2) hours during school vacations (summer). A majority work on farm/ranch that is operated by their parents.

Among farm adolescents, 93.3% self-rated their physical health as excellent or good whereas 82.6% self-rated their mental health as excellent or good. The most common chronic health condition diagnoses were anxiety (18.9%), depression (6.6%), and asthma (4.1%).

Among farm parents, 60.1% met the criteria for at least mild depression based on the PHQ-9 screening instrument (Table 3). Almost a quarter (24.6%) met the criteria for mild depression, 23.8% met the criteria for moderate depression, and 11.5% met the criteria for moderately severe depression. Similarly, 54.9% of farm parents met the criteria for at least mild generalized anxiety disorder (GAD). Nearly a third (31.3%) met the criteria for mild GAD, 18.9% met the criteria for moderate GAD, and 4.9% met the criteria for severe GAD.

Table 4 shows the prevalence of symptoms of depression among farm adolescents and 60.7% met the criteria for at least mild

depression based on the PHQ-A. Over a quarter (26.2%) met the criteria for mild depression, 22.1% met the criteria for moderate depression, and 11.5% met the criteria for moderately severe depression. Over two-thirds (67.2%) of adolescents met the criteria for separation anxiety disorder, 60.7% met the criteria for panic disorder, and half (50%) met the criteria for school avoidance (Table 5).

Correlations among proposed indicators for the FSM are shown in Table 6. For this analysis, all indicators have been scaled in a similar direction (22), and so these correlations are expected to be between 0 and 1. As a measure of economic hardship, per capita income by itself showed relatively low correlations, even with other economic measures ($r = 0.11$ with negative financial events, $r = 0.20$ with financial needs, $r = 0.17$ with financial situation, and $r = 0.27$ with debt). The economic measure most associated with parent depressed mood was debt ($r = 0.67$). Parent depressed mood was in turn highly associated with adolescent depression ($r = 0.83$), social anxiety ($r = 0.54$), and generalized anxiety ($r = 0.69$).

TABLE 3 Symptoms and severity of depression and anxiety among farm parents ($N = 122$).

	Farm parents (P1) *N* (%)
PHQ-9	
None (0–4)	48 (39.3%)
Mild (5–9)	30 (24.6%)
Moderate (10–14)	29 (23.8%)
Moderately severe (15–19)	14 (11.5%)
Severe (20+)	1 (0.8%)
GAD-7	
None (0–4)	55 (45.1%)
Mild (5–9)	38 (31.1%)
Moderate (10–14)	23 (18.9%)
Severe (15+)	6 (4.9%)

TABLE 4 Prevalence of symptoms of depression among farm adolescents ($N = 122$).

	Farm adolescents *N* (%)
PHQ-A category and score	
None (0–4)	48 (39.3%)
Mild (5–9)	32 (26.2%)
Moderate (10–14)	27 (22.1%)
Moderately severe (15–19)	14 (11.5%)
Severe (20+)	1 (0.8%)

TABLE 5 Prevalence of symptoms of anxiety related disorders among farm adolescents ($N = 122$).

Anxiety related disorder	*N* (%) meeting cut-off criteria[a]
Panic disorder or significant somatic symptoms	74 (60.7%)
Generalized anxiety disorder	55 (45.1%)
Separation anxiety disorder	82 (67.2%)
Social anxiety disorder	47 (38.5%)
School avoidance	61 (50.0%)

[a]Cut-off scores for probable anxiety vary depending on type of anxiety disorder.

4. Discussion and conclusions

Farm families play a critical role in ensuring a safe and adequate food supply. According to the United States Department of Agriculture's 2017 Agricultural Census, over 85% of all farms and just over 60% of land are family held, meaning owned and operated by individual or family units (1). Ensuring the health and safety of agricultural producers in the United States and worldwide is an international priority. Economic and environmental conditions have threatened the mental health of agricultural producers, who experience higher prevalence of anxiety, depression, and higher rates of suicide than some sectors of the general population (5, 29, 46). While youth are known to live and work on farms (1), limited research has examined the relationship between farm stress, parental mental health, and adolescent mental health. This five-year study will offer updated information about the shared experience of farm stress and mental health within farm families.

In this sample of 122 farm families, we observed a high prevalence of farm adults that were experiencing at least mild symptoms of anxiety and depression. Among adults, nearly a quarter met the criteria for mild depression and moderate depression and 11.5% met the criteria for moderately severe depression. While the PHQ-9 was used to screen for depression, and not diagnose, the observed distribution of respondents experiencing symptoms of at least moderate depression exceeds that of the general population. According to results from the National Health and Nutrition Examination Survey (NHANES), 8.5% of adults had depressive symptoms in 2019, characterized as a score of 10 or greater on the PHQ-9 in 2019. This statistic increased to 27.8% during the COVID-19 pandemic (March–April 2020) (47). It is important to note for comparison that farm family data was collected in the summer of 2021. For additional comparison, though the instruments to assess for depressive symptoms differ, according to the 2020 National Survey on Drug Use and Health (NSDUH), 8.4% of adults aged 18 and older experienced at least one major depressive episode in the last 12 months, characterized by "a period of at least 2 weeks when a person experienced a depressed mood or loss of interest or pleasure in daily activities, and had a majority of specified symptoms, such as problems with sleep, eating, energy, concentration, or self-worth" (48).

Nearly a third of adult participants in our sample met the criteria for mild Generalized Anxiety Disorder, and 18.9% and 4.9% met the criteria for moderate and severe GAD, respectively. Again, the GAD-7 was used to screen for GAD and not diagnose. Among the general population, in 2019, 3.4%, and 2.7% of adults experienced moderate or severe symptoms of anxiety, respectively (49). Among farm adults in our study, only

TABLE 6 Matrix of Pearson correlation coefficients among indicators of the Family Stress Model ($N = 122$).

	2	3a	3b	3c	4	5a	5b	6a	6b	7a	7b	7c
1. Per capita income	0.11	0.20*	0.17	0.27**	0.25**	0.22*	0.24**	0.18*	0.14	0.08	−0.05	0.13
2. Neg financial events		0.82**	0.55**	0.45**	0.37**	0.35**	0.23**	0.36**	0.27**	0.29**	0.32**	0.37**
3a. Economics–financial need			0.52**	0.46**	0.39**	0.33**	0.25**	0.26**	0.17**	0.25**	0.30**	0.38**
3b. Economics–financial situation				0.56**	0.44**	0.41**	0.50**	0.41**	0.35**	0.30**	0.24**	0.37**
3c. Economics–debts					0.67**	0.58**	0.44**	0.54**	0.45**	0.60**	0.47**	0.59**
4. Parent depressed mood						0.65**	0.48**	0.49**	0.37**	0.83**	0.54**	0.69**
5a. Caregiver conflict hostility							0.29**	0.70**	0.57**	0.60**	0.46**	0.53**
5b. Caregiver conflict warmth								0.28**	0.25**	0.40**	0.13	0.27**
6a. Parenting style involvement									0.84**	0.44**	0.28**	0.37**
6b. Parenting style strictness										0.34**	0.20*	0.26**
7a. Adolescent: depressed mood											0.55**	0.67**
7b. Adolescent: social anxiety												0.75**
7c. Adolescent: generalized anxiety												1.0

*$p \leq 0.05$, **$p \leq 0.01$.

45.1% experienced no or minimal symptoms of anxiety, whereas among the general population, 84.4% experienced no or minimal symptoms in 2019 (49). More recent comparisons of the adult, general population in the United States from national public health datasets are not available. The prevalence of symptoms of depression and anxiety was higher among adult farmers in our study than the general population; however, the distribution of respondent by depressive category is consistent with what has been previously reported among Midwestern farmers and young adult farmers and ranchers (5, 9). The results from this study provide further evidence that agricultural producers experience depressive symptoms more than the general population and additional research and interventions are needed to identify services and resources for farmers and ranchers.

Among farm adolescents in our study, 22.1% met the criteria for moderate depression, 11.5% met the criteria for moderately severe depression, and 0.8% met the criteria for severe depression, based on the PHQ-A. In the U.S. it is estimated 4.1 million adolescents (aged 12–17), or 17.0%, experience at least one major depressive episode per year (48). Among the general population, adolescent females and adolescents reporting two or more races were more likely to experience a major depressive episode. The prevalence of farm adolescents meeting the criteria for moderate and moderately severe depression is high when compared to the general population, especially when considering the sample was largely male and largely Caucasian, which are not demographics considered at high risk of depression. However, direct comparisons cannot be made given different sampling strategies, timing, and instruments. Nearly half (45.1%) of farm adolescents in our study met the criteria for generalized anxiety disorder and 67.2% met the criteria for separation anxiety disorder (50). These statistics are higher than what is observed in the general population, where an estimated 31.9% of adolescents show any anxiety disorder; however, direct comparisons are difficult to make, and reliable comparisons are dated. Although resources and services to serve adolescents and youth have increased, it remains unclear if resources and services specific to farm adolescents are available and disseminated in rural areas.

Statistics from national public health surveys suggest a mental health crisis in the U.S. (48). Conversations around mental health in the U.S. have increased in response to economic conditions and the COVID-19 pandemic as many Americans experienced isolation, uncertainty, and financial pressure (51). Farm adolescents and farm adults in our sample reported symptoms of anxiety and depression at relatively high rates. Importantly, many Americans experience barriers to mental health care such as cost, access, and stigma (52), and the issues may be exacerbated in rural communities, where services are often limited. Without appropriate intervention, these symptoms in farm adolescents may indicate risk for more serious mental health issues in the future. Also, if not addressed, these issues reported by farm youth may add to the challenges youth face in continuing their family traditions of careers in farming and ranching.

Among our sample of farm adults 34.7% and 50.4% self-rated their mental health as excellent and good, respectively. Similarly, among farm adolescents, 35.5% and 47.1% self-rated

their mental health as excellent and good, respectively. Single item, self-rated mental health (SRMH) measures to assess mental health are increasingly popular in epidemiological surveys, because they reduce respondent burden and simplify analyses (53). Some analyses have demonstrated moderate correlation between SRHM and various mental health scales, including the PHQ-9 (54, 55). However, when considering our sample of adults, 85.1% rated their mental health as excellent or good and at the same time, 60.1% met the criteria for at least mild depressions, and 54.9% met the criteria for at least mild anxiety. These conflicting results suggest disagreement between self-rated and symptom-based mental health measures among the farmers. While validating single-item measures is beyond the scope of this study, there are important implications for farmer mental health. Poor or fair SRMH has been associated with increased healthcare utilization (56, 57). Therefore, the perception of excellent or good mental health, when clinical disorders may be present, may preclude farmers from seeking and obtaining mental health care, delaying treatment, and potentially reducing overall quality of life.

Results from this study show relatively low correlation between per capita income and negative financial events, financial needs, financial situation, and debt. Importantly, parental depressed mood was significantly correlated with all economic indicators, income, and debt. In addition, and perhaps one of the most important result of this analysis, the correlation between parental depressed mood and adolescent depressed mood was high (0.83). These results are very consistent with previous applications of the Family Stress Model and suggest there is a relationship between emotional distress and financial and economic situations among both farm parents and farm adolescents. This relationship has been documented in previous research of non-farm families (58, 59). The small sample size ($N = 122$) precluded the research team from further statistical modeling in line with the Family Stress Model, however, this is an area for future analysis in future years.

While preliminary results contribute to the body of knowledge around farm family mental health, there are limitations to consider. The small sample size precluded full statistical modeling of the Family Stress Model as demonstrated in previous applications of the theory (19, 21–23). However, in the future, pooling responses from several years is expected to provide more stable estimates and an opportunity for this statistical approach. Additionally, the relatively small sample size and the single point-in-time assessment threaten the generalizability of results. Mailed recruitment efforts yielded very low responses from farm families ($n = 18$) which encouraged the research team to consider online recruitment efforts, including using social media. Online recruitment resulted in a compromised survey link and thousands of questionable survey responses. While the research team employed evidence-based best practices for identifying illegitimate responses (44, 45), this is certainly a limitation of the data. However, recruitment of farm families into research is challenging given no centralized location and geographical distribution. Online efforts, including the use of social media, can reach a large number of people at a relatively low cost (60). Parents were required to consent their adolescent to participate in the study, and parents were informed the adolescent survey would inquire about stress, mental health, and substance use, which could have introduced bias among adolescents who did not want to respond to items truthfully. To reduce this bias, adolescent surveys were sent directly to an adolescent's email and they were encouraged to take the survey in a quiet, private location free from distractions. We also emphasized that survey results were anonymous, meaning we could not link responses to a specific person. Social desirability bias is often diminished when self-administered surveys are employed (61). Here, as with all surveys, uncertainty is introduced by missing items which may have been selectively skipped, but rates of missing responses were relatively low. Finally, comparisons of symptoms of depression and anxiety between farm and non-farm adults and adolescents should be considered with caution. The year, methodologies, and instruments used in data collection differed and direct comparisons could not be made.

To our knowledge, this is the first published study to examine the correlation between farm parent and adolescent mental health since the Conger et al., initial study of farm and rural families in Iowa (62). The results here, when considered with what is known, underscore the need for continued research including surveillance and interventions related to the mental health of farm families. A major strength of this study, as it continues, will be the application of the Family Stress Model, which has been well-examined and applied to various audiences including farm and rural families. The FSM remains a useful framework for conceptualizing the impact of economic pressure on farm adult and adolescent mental health, especially when considering economic challenges associated with farming remain a consistent and leading stressor among agricultural producers (2, 5, 6, 8, 63). The use of validated instruments to assess economic hardship, parenting styles and relationships, adult mental health, and adolescent mental health further strengthen the study.

Adolescent mental health is a public health priority, and increased attention on agricultural producer mental health has led to a needed influx of research, resources, and services to meet the unique need of the occupation. This research contributes important information about the prevalence of symptoms of anxiety and depression among a sample of farm parents and adolescents and correlations within families for consideration of resource and service development. Importantly, farm parent and adolescent mental health, specifically, symptoms of depression and anxiety are highly correlated. Additional research is required to further understand these relationships and the risk and protective factors for adolescent and adult mental health. Additionally, mental health resource and services should consider the family and influence of farm economics on farm family mental health.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, upon request, when the funding cycle is completed.

Ethics statement

The studies involving human participants were reviewed and approved by University of Illinois Urbana-Champaign Institutional Review Board. Written informed consent to participate in this

study was provided by the participants' legal guardian/next of kin.

Author contributions

JR and RB conceptualized the study. JR collected data. RB conducted data analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Needs assessment survey for enhancing United States child agricultural injury prevention capacity: Brief report

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The dissemination of childhood agricultural safety and health information and resources through organizations that farmers trust enhances implementation and the Socio-Ecological Model can help identify these organizations. However, to become effective partners in improving agricultural health and safety, organizations need to build capacity in child agricultural safety and health, thus, more information is needed about these organizations' current practices, needs, and capacity for leadership, policy makers, and knowledge mobilization. An online survey was administered to organization leaders with an interest in child agricultural injury prevention, chosen through agricultural health and safety organization membership lists. Invitations to participate in the online survey were mailed to 95 organization leaders with three weekly reminders, resulting in participation from 50 organization leaders (53% response rate). Respondents indicated a high level of awareness of child agricultural injuries, yet few were actively engaged in injury prevention. When asked about "needs" for building capacity in injury prevention, over half (56%) identified a need for more promotion and dissemination of safety resources and strategies, including ATV safety, no extra riders on equipment, and keeping young children out of the worksite. The only topic that more than half of the organizations (54%) identified as "needing more information" was childhood agricultural injury surveillance. This assessment yielded valuable details for identifying opportunities, priorities, and topics for future collaborations and capacity building. Findings help inform national and international planning committees' work, such as the next iteration of a US National Action Plan for Childhood Agricultural Injury Prevention, scheduled for release in 2024.

KEYWORDS

child, youth, injury, prevention, farm, agricultural safety, needs assessment

1. Introduction

Farms and ranches across the United States often serve as family homes, as well as dangerous occupational worksites. The presence of young children in these worksites is an ongoing public health concern, one more prevalent in agriculture than other industries, and one that continues to fuel researchers and injury preventionists across the field. There are far too many traumatic injury reports involving young children, some of whom were under the presumed supervision of a nearby adult (1–3). Beyond the news media reports, studies in the peer-reviewed literature

continue to reaffirm the presence of young children in these dangerous worksites, often not working at the time of injury (4–8). While there is no central repository of child agricultural injury data in the United States, current data indicates that every day about 33 children are seriously injured and about every 3 days a child dies in an agricultural related incident (9).

For many years, the primary responsibility for ensuring children hired to work in agriculture were protected from agricultural hazards rested within the regulatory system, holding farm owners accountable to abide by child labor in agriculture regulations (10). However, children working on family farms are exempt from these regulations, and the regulations cover non-working children, leaving the protection of these children to the parents' discretion. In addition, the age minimum for hazardous work in agriculture is age 16 versus 18 in non-agricultural industries (10). Consequently, since 2009, more youth have died working in agriculture, than in all other industries combine (9). The U. S. Department of Labor, with input from NIOSH and safety advocates, proposed long overdue updates to the regulations in 2011 and for the following 7 months heard an uproar from members of the farming community denouncing the role of government with respect to young workers in agriculture. Per a directive from President Obama, the DOL withdrew the proposed rules for children working in agricultural vocations (11). The government's response was for United States Department of Agriculture (USDA) to promote safety education. In 2013 the USDA awarded Penn State funds to develop a clearinghouse of youth agricultural safety Curricula (12).

The brouhaha over proposed, then withdrawn, child labor in agriculture regulations updates sent a loud message that the farming community wants to manage the role of children with minimal government intrusion, with comments such as "It is really sad that government is getting involved in how we teach our kids to grow up on farms" (13). So, who and what influences farm parents' safety practices? The economics of agriculture is a primary driver of decisions and many organizations and corporations influence those economics (14, 15). While the relative strength of influence is not known, it is believed that production systems, insurers and bankers are influential (16). Additionally, institution/organization-level agricultural-focused youth-serving organizations such as National FFA and major farm organizations (e.g., Farm Bureau) often guide decisions made by farm owners.

Ideally, efforts to ensure protection of children from agricultural injuries and deaths would be guided from the highest level of the Socio-Ecological Model (SEM)—public policy (17). However, despite the fact that agriculture is one of the most hazardous industries for adults and children alike, it is the least regulated with regard to child labor (10). Regulations that do exist have limitations because: (1) most farms have fewer than 11 employees and are exempt from OSHA regulations; (2) family farms have exemptions from child labor in agriculture regulations; (3) current regulations are outdated; (4) options for enforcing those regulations that exist are hampered by the sheer geographic dispersion of farming; and (5) regulations do not provide protections for non-working children (10, 18, 19).

As regulations provide limited protections, a strategy is needed to help organizations identified in the SEM to build capacity in child agricultural safety and health. Figure 1 describes ways in which agricultural safety interventions can and should incorporate all levels of the SEM, notably the impact institution/organization and community-level interventions can have in agricultural populations (Figure 1). Increased collaboration between agricultural safety and health organizations and stakeholders, including down to the individual levels, can be a powerful tool for precipitating change.

An ideal strategy for child agricultural safety and health that engages at all levels of the SEM is described in Goal V of the 2012 Blueprint for Protecting Children in Agriculture, indicating the need to "accelerate the agricultural industry and associated organizations' adoption of safety and health standards that protect children in agriculture" (20). As one of the leading research centers focused on United States child agricultural health and safety, the National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS) leads the efforts to assess and expand the organizational capacity of stakeholder organizations.

The purpose of this study was to assess the items (e.g., knowledge, training, resources) external agricultural safety and health stakeholder organizations need to build their capacity in child agricultural injury prevention (CAIP), and use these findings to generate recommendations for future NCCRAHS activities. The project leveraged current relationships with organization executives to reach into networks of leaders across domains of youth serving organizations, insurance companies, agricultural media, and agricultural bankers. This "reach" could also help increase the number and spectrum of groups that incorporate a focus on childhood farm safety into their ongoing systems, policies and communications with constituents and members.

2. Materials and methods

2.1. Methods

The survey instrument was developed by an interdisciplinary team of researchers and included questions related to respondent organizations' current and planned behaviors and priorities of child agricultural injury prevention. The survey instrument was pilot tested and refined. It is available upon request. The research protocol was expedited in an ethics review by the Marshfield Clinic Research Institute Institutional Review Board, as it involved minimal risk to the participants and data was collected for research purposes using a survey. Participants confirmed their consent to participate by completing and submitting the survey. The survey sample was procured from membership lists of several key organizations, including the Childhood Agricultural Safety Network (CASN) the Centers for Agricultural Safety and Health, funded by the National Institute for Occupational Safety and Health (NIOSH), the International Society for Agricultural Safety and Health (ISASH), and the Agricultural Safety and Health Council of America (ASHCA).

These aforementioned member lists were combined with an internal NFMC contact list; duplicates were eliminated. The lists were edited to include only organizations with an interest in child agricultural injury prevention, as determined by our research team. The recipient list contained a total of 102 United States organizations. The research team reviewed the organizations and identified one individual contact from each organization to participate whom it felt could respond on behalf of the organization, typically the director or President.

The project team developed and administered an online REDCap (Research Electronic Data Capture) survey to gather information from the 102 organizations identified. Study data were collected and managed using REDCap electronic data capture tools hosted at Marshfield Clinic Research Institute (21, 22). REDCap is a secure, web-based software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for data integration and interoperability with external sources.

A modified Dillman approach was employed with an incentive–a $2 USD bill–with each mailed invitation (23). The hard copy invitations, which included a link to the online REDCap survey, were mailed to the identified stakeholder in each organization in December 2019. Seven of the mailings were returned unopened, with no forwarding addresses found. Three weekly reminders were emailed to all participants, as the use of a single survey link precluded identifying who had already responded. Completed responses were received from 50 of the 95 recipients, representing a 53% response rate. Our analytical sample for this paper was limited to the 50 respondents.

The survey instrument developed in REDCap used branching logic, which enabled participants to be directed to questions based on their self-identification as a CASN member and/or as a representative of a NIOSH Ag Center. If participants did not identify as either, they were directed to a set of questions for other organizations. The survey contained 20 questions, although due to branching logic, no participants were asked more than 15 questions. The survey was pilot tested with individuals from the target organizations, who were not identified as potential participants.

3. Results

Participants represented a good cross section of agricultural safety and health stakeholders, including academia (Researchers, Extension Specialists, and Teaching), 4-H Educator, insurance, Farm Bureau, and health and safety organizations. No responses were received from equipment manufacturers, agricultural cooperatives, bankers/lenders, and high school agricultural teachers, youth organizations or County/Regional Extension Educators/Agents. However, it is possible this is due to how the participant self-identified. For example, some organizations may be youth focused safety and health organizations, and selected as safety and health, rather than as a youth organization.

When participants were asked to select all organizations to which they were a member, ISASH was the most frequently selected (53%), followed by Other (40%), CASN (33%), NIOSH Ag Centers (31%), ASHCA (27%) and the American Society of Agricultural and Biological Engineers (24%). The "Other" category of respondent organizations included the American Association of Agricultural Education, American Psychological Association, National Safety Council, American Society of Safety Professionals, National Association of State, Public Health Vets, Occupational Safety and Health Association, National Fire Protection Association, International Rural Health Association, Farm Bureau, Rural Health Association, National Association of Community Health Centers, Grain Handling Safety Council, NCERA, and SAE (see Supplementary material for a further detailed breakdown). Most of the organizations (84%) indicated that agriculture-related injuries and fatalities to children and youth were either a major problem or somewhat of a problem. Despite the perceived seriousness of the problem, less than a third of the respondents (31%) worked on child agricultural injury prevention initiatives frequently or all the time. However, when asked to characterize their organization's interest level in participating in CAIP activities in the next 5–6 years,

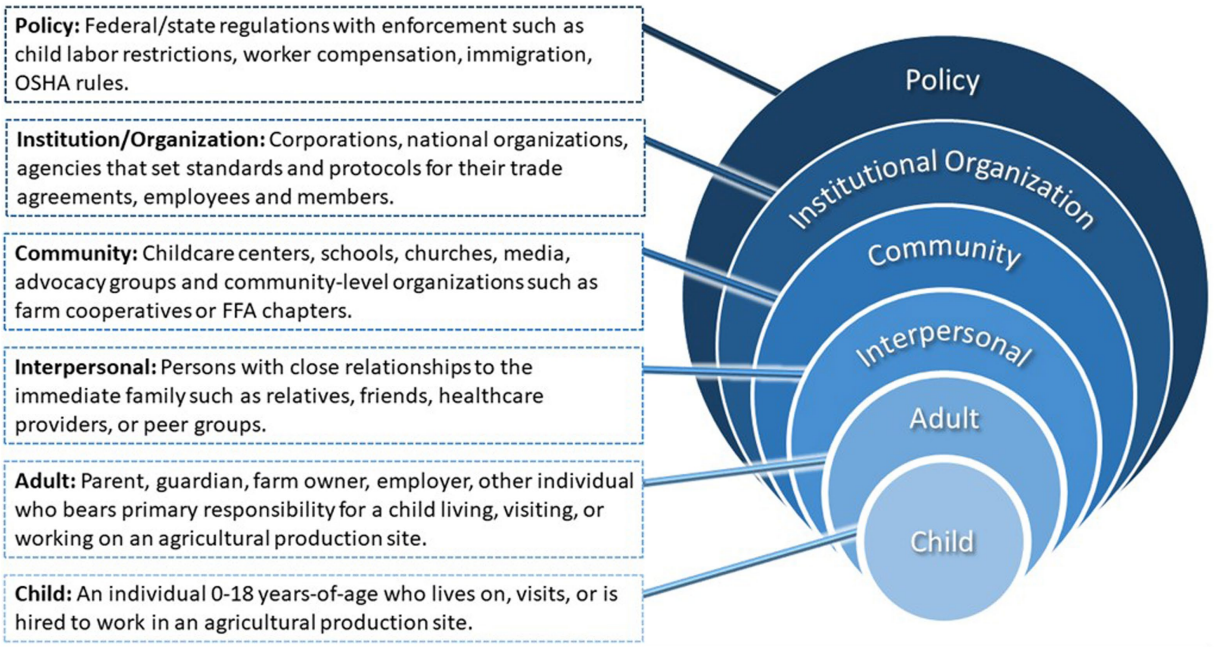

FIGURE 1
Socio-ecological model (modified for agriculture).

80% of participants indicated they were very interested or somewhat interested.

Promotion and dissemination of child agricultural safety resources and tools was identified by respondents as the strongest need overall (mean = 56%), when given a list of 13 topics (Figure 2). Topics identified as needing the most promotion and dissemination were ATVs/UTVs (70%), extra riders on equipment (70%), and keeping young children out of the worksite (70%). Injury surveillance was the only topic that more than half of the respondents identified as needing more information and resources (54%).

There was also some impact of the respondents' organization's role in how they viewed topics of agricultural safety and health. For example, a majority of insurance respondents viewed community gardens as needing no further promotion and dissemination, while also reporting a need for greater information and dissemination for animal safety than academia or health and safety organizations. Generally, academia and health and safety organization respondents reported a greater need for more information and dissemination across all topics, while insurance and extension respondents were more conservative in several topics including youth supervision and grain/confined spaces.

Participants were also asked to list any other topics that needed to be addressed. Railroad safety, weather safety and mental health were listed by three separate participants, two participants listed hearing protection and three participants indicated a need for more Spanish resources.

The resources most identified as being in current use by survey participants are the Child Agricultural Injury Fact Sheet (60%), Ag Injury News (54%), and the Agricultural Youth Work Guidelines (52%; see Figure 3) (9, 24, 25). Participants were also invited to list any other resources they have used or will use. One participant listed the mini grant program and one participant listed Tick ID Cards. Another participant wrote: "*We have distributed nearly all of the resources available from the Children's Center—they are a great complement to our Center's materials and provide a conversation starter with agricultural families*" (26, 27).

Through the use of branching logic, this instrument was able to direct specific questions to CASN members to help guide their future efforts. The top three CAIP activities *CASN members* indicated an interest in were promoting existing campaigns (73%), networking opportunities (67%), and co-branding resources (67%), although several other activities were also identified by more than half of the CASN members (see Figure 4). Although asked, no participants suggested other activities. Through branching logic, the NIOSH Regional Agricultural Centers representatives' interest in collaboration was solicited in an effort to inform future work. Results from the centers revealed interest in collaborative research projects (85%), promotional campaigns (69%) and co-branding resources (69%), while other organizations (did not self-identify as CASN or NIOSH Ag Center) were most interested in co-branding resources (60%). The" Other" activity that NIOSH Agricultural Centers indicated they were interested in was "Extension/Outreach activities."

4. Discussion

This survey found a fairly high level of awareness of child agricultural injuries, yet few of respondents are actively engaged in prevention activities. While this survey did not explicitly ask participants why they were not engaged, it may be due to a lack of materials or resources, as many respondents reported promotion and dissemination as the largest need (56%). Re-surveying participants as the COVID-19 pandemic becomes less of a priority could further shed light on this discrepancy. Plans are underway to conduct a survey with CASN members in early 2023, which will assess many of these same items, allowing for comparison across timeframes and expansion to include topics such as methods of dissemination.

Another promising finding is that 60% of CASN respondents were interested in developing new public service safety campaigns. This represents ongoing interest and commitment to the field. Since these data were collected, this has sparked new program planning within CASN, including the formation of a newly appointment leadership team with members external to NCCRAHS. At the time of this writing, the leadership team is soliciting member input on topic area priorities for a new campaign.

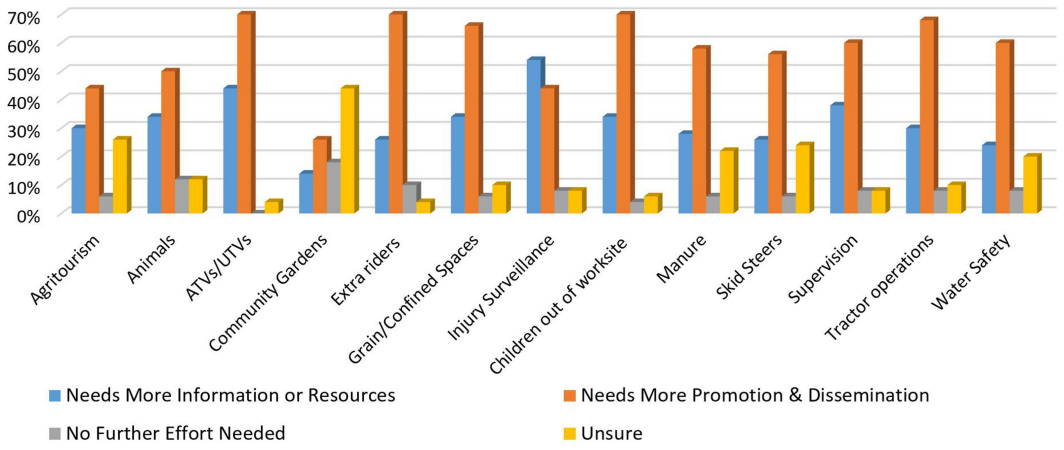

FIGURE 2
Child Ag safety and health topic needs.

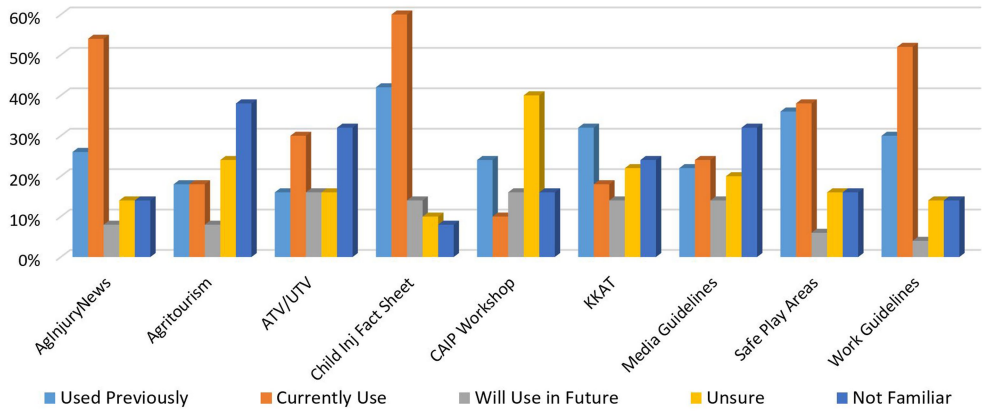

FIGURE 3
Resource usage.

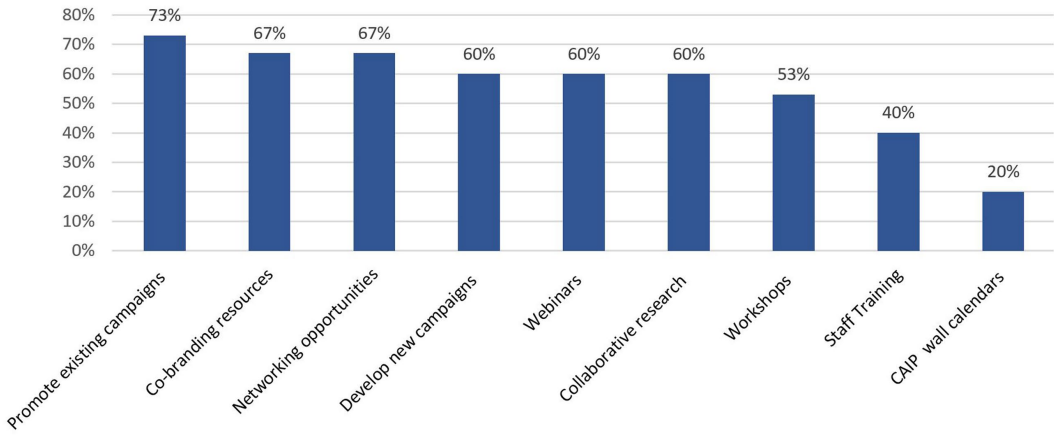

FIGURE 4
CASN member interest in CAIP activities.

Injury Surveillance was the only topic identified by more than 50% of all participants as needing more information or resources. Consistent with recent literature, agricultural injury surveillance lacks federal-level support, funding, and dissemination (28, 29). While some datasets and methods have surfaced and shown increased utility, much discussion is underway among stakeholders and federal agency officials regarding ideal and optimal fatal and non-fatal injury surveillance strategies for the industry (4, 28, 30–32). Meanwhile, several state-based "farm fatality reports" include child fatalities, whether the child was working at the time of the incident or not, capturing the integration of the worksite and home present on many family farms and household youth (33–36).

The findings of this study have helped better inform research strategies and dissemination efforts, including the expanded child agricultural safety and health workshop series. The research team has also refreshed the Child Agricultural Injury Fact Sheet, releasing a 2022 version (9). Respondents of this survey and anecdotal evidence from other readers have shown that this report continues to be of great interest among agricultural safety and health stakeholders and the news media. Reporters from agricultural news outlets, as well as mainstream media regularly contact NCCRAHS for injury data and information, and their articles often include quotations from staff and links to resources such as the Child Agricultural Injury Fact Sheet (37).

Still, we are fully aware of the results' timeliness. The responses provide actionable evidence, but respondents' interests and priorities have very likely shifted since January of 2020. Additionally, respondents appeared to report a greater need for resources and dissemination in areas more pertinent to their organizations' goals in several topic areas such as community gardens and supervision. We recommend referencing these findings as informational and supplemental to a more current assessment of stakeholder needs. Results from the planned CASN survey will enable us to compare results with this current assessment, illuminating changes in the field over the last several years.

4.1. Limitations

This assessment relates largely to family farm child safety, minimally touching on hired youth or migrant, Anabaptist, Hispanic, or other underserved youth. It also revealed a lack of engagement in child agricultural injury prevention activities among survey participants, but provided limited information on the reasons for the

lack of engagement. Participants were also chosen from known, existing Listservs and professional organizations that, while broad in scope and inclusion, likely did not capture all potential aspects of agricultural health and safety organizations. This survey did not include mental health as a topic area question, though one respondent did mention this in an open-ended response question; it is possible more organizations are interested or actively working in mental health but did not have the opportunity to report so. In addition, the results of this study were collected late 2019, early 2020. While these findings are useful in planning and future activities, funding allocations, and priorities, the priorities of the respondent organizations may have shifted over the past 2 years. Some of these shifts as a direct result of the global COVID-19 pandemic, others as a result of federal funding cycles. Specifically, the NIOSH Regional Agricultural Centers have undergone a competitive renewal process, submitting proposals for new projects, often in new directions from their past 5-year cycles.

4.2. Conclusion

This needs assessment yielded valuable information from leaders of US organizations that address safety and health in agriculture. Findings indicated that most are interested in participating in child agricultural injury prevention activities, including opportunities for future collaborations. Results also highlighted the value of several existing resources that should be maintained. In addition, the survey revealed gaps in information on certain topics and needs for further promotion and dissemination across a variety of topics. This assessment yielded critical information and is an important step in identifying opportunities and topics for future collaboration.

Agriculture remains one of the most hazardous industries in the United States, with 33 children seriously injured daily (9). The information gained in this study on the knowledge, interests and needs of external stakeholder organizations will inform NCCRAHS' future work and collaborations, helping other organizations to build their capacity in child agricultural injury prevention.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Marshfield Clinic Research Institute Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MS, BW, RB, and BL participated in the conception or design of the work, acquisition, analysis or interpretation of data for the work, drafting the work and revising it critically for important intellectual content, final approval of the version to be submitted and published, and all agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1059024/full#supplementary-material

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Safety guidelines for youth agricultural work in the United States: A description of the development and updating process

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To reduce the prevalence of youth injuries and fatalities in agricultural settings, safety professionals considered developing a guideline-focused intervention for how and when youth should conduct farm chores. In 1996, the process to create guidelines started, which then expanded to include professionals from the United States, Canada, and Mexico. This team used a consensus driven approach to develop the guidelines and launch the North American Guidelines for Children's Agricultural Tasks. By 2015, research related to the published guidelines indicated a need to incorporate new empirical evidence and develop dissemination plans based on new technologies. The process for updating the guidelines was supported by a 16-person steering committee and used content experts and technical advisors. The process yielded updated and new guidelines, now called Agricultural Youth Work Guidelines. This report responds to request for further details on the development and update of the guidelines and describes the genesis of the guidelines as an intervention, the process for creating guidelines, recognition of the need to update guidelines based on research, and the process for updating guidelines to assist in others engaged in similar types of interventions.

KEYWORDS

youth, work, guidelines, agriculture, intervention development

1. Introduction

In the late 1980s, an informal group of farm safety advocates began discussing various approaches for addressing the high frequency of serious injuries and fatalities of children across the more than 2 million agricultural operations in the United States. At that time, there were no public- or private-sector organizations dealing with safety and health specific to children living, working, or visiting farms. Since then, child safety advocates and stakeholders representing farm families worked together to develop an intervention aimed to prevent child injuries and fatalities within agricultural settings. Since the launching of the original guidelines in 1999, there have been requests for a description of the process used to create the guidelines. The updating of guidelines renewed calls for a thorough description of the process. Individuals have requested the description to reference the process used to create the guidelines for individuals implementing and conducting research with the guidelines and replicate the process in other health and safety topics. This report describes the genesis of the guidelines as an intervention,

the process for creating guidelines, recognition of the need to update guidelines based on research, and the process for updating guidelines to assist in others engaged in similar types of interventions.

2. North American Guidelines for Children's Agricultural Tasks

The development of the North American Guidelines for Children's Agricultural Tasks (NAGCAT), which later became Agricultural Youth Work Guidelines (AYWG), started in the late 1980s. To address the prevalence of youth injuries and fatalities in agricultural settings, safety professionals considered developing recommendations for how and when youth should conduct farm chores. However, farm organization representatives expressed concern and skepticism regarding written guidelines. Further, pediatricians insisted there was no "wiggle room" for children to be present in any occupational setting. Given the spectrum of perspectives on guidelines, standards or protocols, it was evident that any recommendations required a consensus process that included all stakeholder groups.

In 1996, a formal proposal for creating working guidelines for children in agriculture was submitted within a larger grant application for an agricultural safety center of excellence funded by the National Institute for Occupational Safety and Health (NIOSH). A small level of funding was secured to form a working group, led by a core team in Marshfield, WI, United States. While initially planned to take about 1 year to complete, the multidisciplinary team grew, and the complexity of creating work guidelines became daunting.

Substantial funds for project expansion came with the establishment of the NIOSH-funded National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS) in 1997. The three-member core team established in 1996 was joined by 12 external advisors from the United States, Canada, and Mexico. Twice-yearly in-person meetings were scheduled for a 2-year endeavor. Inclusion/exclusion criteria for activity and documentation parameters were established. A definition and process was set for what constituted group "consensus" such as requiring three-fourths of the team members' agreement. Early in the process, advisors with expertise in child development made a convincing argument for using child development principles (physical, social, intellectual, and emotional abilities) versus age as demarcations for when a child is capable of completing a task. At the same time, several risk managers insisted that work tasks be described using the job-hazard-analysis framework commonly used across industries (see U.S. Department of Labor, *Job Hazard Analysis* (1) for more information). The full team including all advisors agreed upon these strategies, setting the stage for a new approach to recommending guidelines for children's work in agriculture.

The next question was "what are the most important jobs or tasks for which guidelines are needed?" Two strategies provided answers to this question. First, existing data sets such as state-level farm fatality reports revealed most common agents of injury to children. Second, a questionnaire sent to state-based farm safety specialists and members of the National Institute for Farm Safety, provided insights on what types of jobs and tasks were conducted by youth in their region. Data from these two sources yielded a list of more than 50 tasks that merited attention. An advisor with marketing expertise in agricultural personal protective equipment (PPE) recommended that the end-product be more than a series of charts and words, so visual depictions of potential printed resources for farm parents were reviewed. The team agreed an illustrator versus a photographer should be employed to convey key components of safety guidelines such as youth engaged in tasks as well as images of various types of PPE to be worn during work activities.

With the basic principles and project timeline established, work began in earnest. The team split up responsibilities. Most of the team was developing the content for each of the work tasks. This started by filling in the job-hazard-analysis framework based on how a task was conducted and often warranted a subsequent review by a producer active in that type of work. For example, for "feeding milk to calves" an advisor drafted the content, then a dairy farmer with children reviewed the step-by-step process, of filling and transporting a filled bottle to a calf hutch, holding the calf, supervising the youth, etc. Once the job-hazard-analysis framework was completed, the individual steps were reviewed by child development specialists to match tasks and hazards with required developmental characteristics of a child, addressing issues such as weight bearing, fatigue, required judgment, and supervision. This team also oversaw the drafting and finalization of each task illustration as well as the layout of how the full-color guidelines would eventually appear. Meanwhile, other team members addressed project management including meetings, documentation, budgets, timelines, and evaluation. By 1998, the guidelines were named the "North American Guidelines for Children's Agricultural Tasks" or NAGCAT.

An overriding issue was preparing the guidelines for acceptance, dissemination, and adoption in the farming community. In the United States, one of the largest and most influential farm organizations is the American Farm Bureau Federation (AFBF; 2). The AFBF is one of many farm organizations that resist adding regulations affecting family farm practices, including parents' rights to engage children in work. Thus, a pivotal step in handling any adverse reaction to the release of guidelines led to an in-person presentation to the AFBF Policy Committee. Although committee members questioned the need for guidelines and had major reservations that, over time, they would become regulations, they voted unanimously to "not take a public position" regarding NAGCAT. The team now felt confident in moving ahead with a highly public announcement about forthcoming guidelines.

Successful Farming magazine was given exclusive advance notice regarding the guidelines and prepared a centerfold fully illustrated story including farm parent interviews, timed with their actual completion. Nearly 200,000 reprints of the 12-page SF article were widely distributed across the United States and Canada. In addition, the National Institute for Farm Safety approved an opening 1999 conference session on NAGCAT that featured the most well-known farm radio broadcaster, Orion Samuelson, along with the National FFA Youth President. Both speakers expressed unabashed endorsement of NAGCAT as a resource intended to match a child's ability with the risks and hazards of a farm task. The tagline of "helping kids do the job safely" conveyed the value of gaining important job skills.

The resulting product of 3 years' of consensus-derived guidelines was a Professional Resource Binder with details of each job-hazard-analysis, the child development assessment for each job, and related materials. For the farming public, the resources were illustrated posters for each job. A full-color poster contained: (a) an illustration

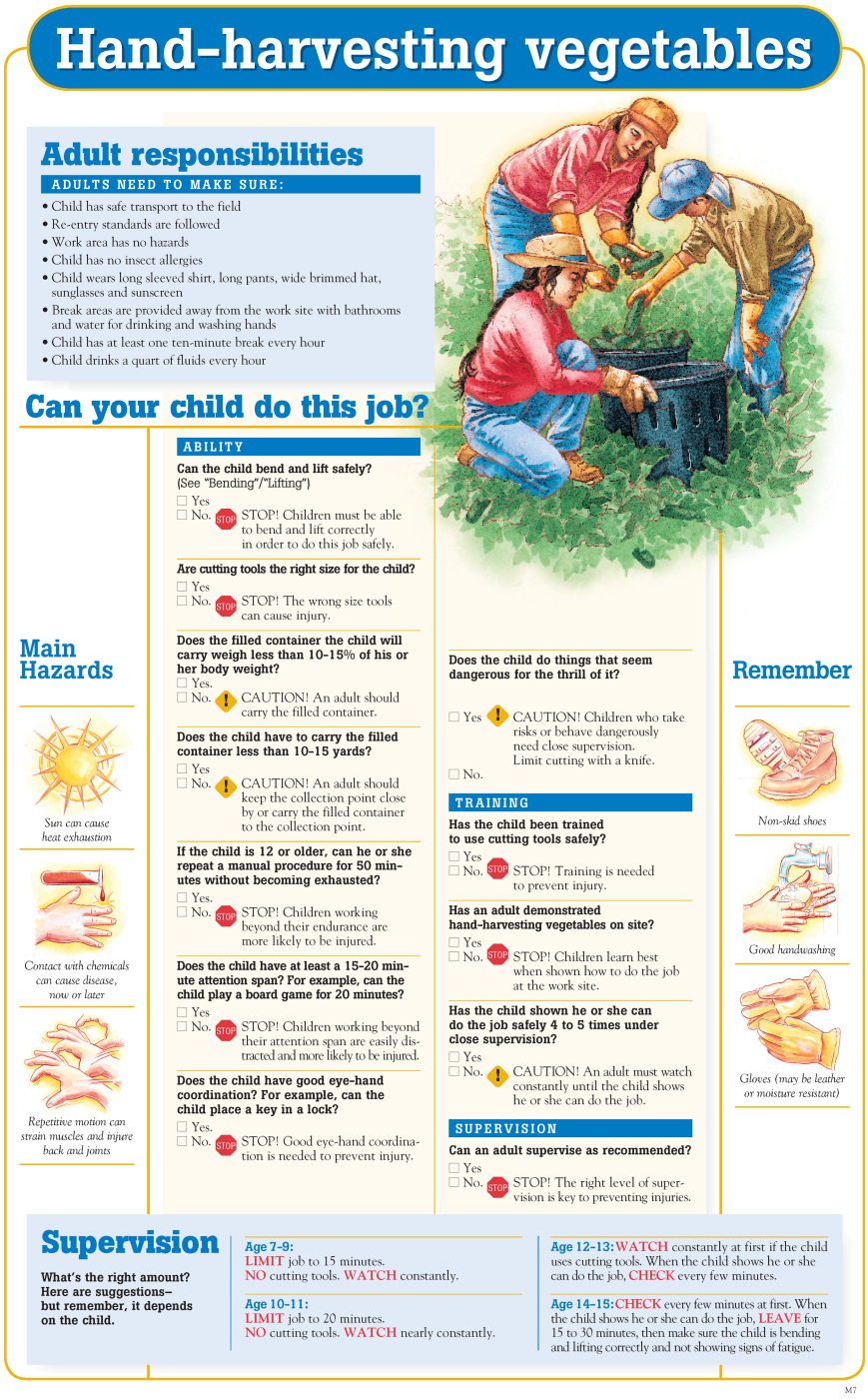

FIGURE 1
NAGCAT poster for hand-harvesting vegetables. Published with permission from the National Children's Center for Rural and Agricultural Health and Safety.

of a child conducting a task correctly; (b) a list of adult responsibilities; (c) main hazards of the task; (d) "things to remember"; and (e) a series of questions about "can my child do this job?" The summary statement recommended the amount of supervision needed based on an age range, noting, "remember, it depends upon the child." In all, 62 specific and four general (e.g., "bending") guidelines were released (see Figure 1). Topics ranged from detasseling corn to working with poultry and operating a tractor with an implement. A supplemental Tractor Operation matrix correlated tractor features (e.g., horsepower and implements) with a lower age range for youth. Guidelines were available to download from the internet and they were printed then bound into six categories, available for purchase from a safety supply vendor. Select guidelines were also available in Spanish and French.

Once farm safety specialists became more familiar with the guidelines, related resources were created, such as a video introduction for presentations to parents and a teacher's manual for classroom use.

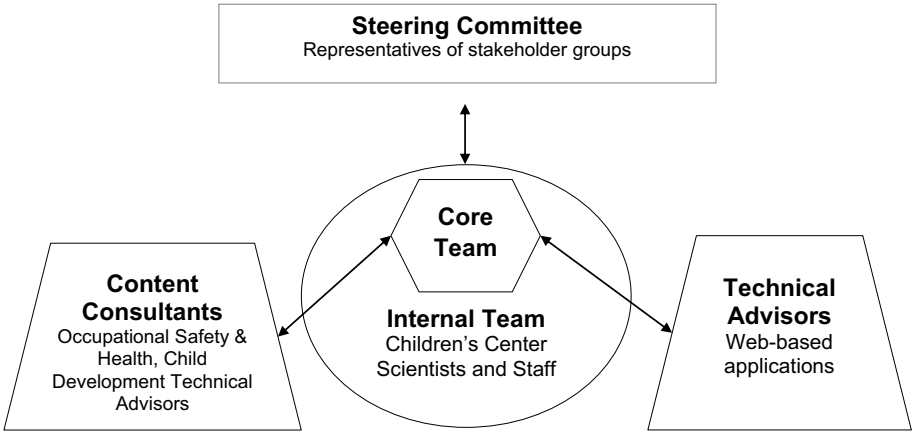

FIGURE 2
Overview of team relationships.

Guidelines were endorsed by the International Labor Organization (ILO) and adapted for use in Sweden, Australia, and among the Hmong population in the Midwest US (3). Because the guidelines were created out of necessity, without a substantial empirical basis, over the next decade NIOSH prioritized research on the validity of guideline content, efficacy of guidelines when applied and related activities.

3. Research findings and need for updating NAGCAT

Reviews of research related to NAGCAT are presented in Marlenga, Lee, and Pickett's 2012 article on implications for the future (4) as well as Doty and Marlenga's 2006 article outlining priorities for the future of NAGCAT (5). Research examined the content of NAGCAT (tractors, jobs involving lifting and carrying, and supervision), dissemination strategies, and efficacy of preventing injuries. Findings indicate the use of NAGCAT could prevent serious injuries (6), including a case–control study that revealed a 50% reduction of work-related injuries for tasks where a guideline was applicable on farms in upstate New York (7).

Implications from research included a need to continue to incorporate new empirical evidence into the guidelines and develop dissemination plans (4). These needs continued to become more evident with emerging scientific evidence on requirements to safely perform work tasks as well as technology's influence on how work was accomplished on farms (8) and how farm parents and supervisors accessed information (9). In late 2015, the illustrated, paper-printed guidelines were available *via* a website, but users needed to download the poster from the website and print it out for reference. A digital version that was mobile responsive to various electronic devices was increasingly important. Finally, although some NAGCAT were adapted to address needs of different cultural populations, it was recognized that some populations did not readily identify with the guidelines (e.g., illustrations only depicted white children) and were inaccessible due to language barriers (10–12). After discussion with key stakeholders, NCCRAHS adopted a strategy to make a "second edition" or "upgraded model," including a mobile-friendly update with relevant content changes, rather than make small changes to select jobs at frequent intervals.

4. Process for updating NAGCAT

National Children's Center for Rural and Agricultural Health and Safety began the process of updating NAGCAT in 2016. Funding was provided through NIOSH, with supplemental funding from CHS Community Giving. The objectives for the process were to account for the following items while updating guidelines: (a) evidence-based recommendations for activities and issues germane to child development (physical, social, intellectual, and emotional); (b) current child ag injury/fatality data; (c) changes in production agriculture; (d) proposed changes in child labor regulations; (e) lessons learned about the consensus development process; (f) information technology and health communications theory/practice; (g) updated recommendations for adults; and (h) priority topics. To ensure these objectives were achieved, a steering committee of 16 stakeholders across agricultural industries (e.g., farmers, American Farm Bureau, USDA, NIOSH, and Progressive Ag Foundation) was formed. The steering committee provided overall guidance on topics, assessed practicality versus science issues, focused messaging, addressed cultural relevancy, and guided overall design/format.

National Children's Center for Rural and Agricultural Health and Safety staff formed an internal team who were responsible for helping create initial drafts/content and planning processes, facilitated relationships/communication with other projects, helped review content, and assisted with promotion and agricultural health and safety researchers, information technology specialists, graphic designers, and media relations specialists. A three-person core team was responsible for the day-to-day activities of the project and met weekly to manage the project's content, technology, communications, and collaborations. The core team worked closely with content consultants who provided expertise in occupational safety and health and child development, and technical advisors who provided expertise in web-based applications. Figure 2 provides an overview of the relationships between different teams involved in the update process.

TABLE 1 Comparison of work guidelines.

	NORTH AMERICAN GUIDELINES FOR children's AGRICULTURAL TASKS	AGRICULTURAL YOUTH WORK GUIDELINES
Acronym	NAGCAT	AYWG
Release date	1999	Final updates released in 2020
Development Process	Consensus of 30 safety professionals; series of in-person meetings, teleconferences, e-communications; and producer consultants	Sixteen-person steering committee; series of in-person and teleconference meetings; use of job hazard analysis frameworks from NAGCAT and published research; expert content consultants
Poster Format	Paper, PDF	Paper, PDF, Read, Print, and Interact
Graphics	Illustrated Drawings	Vector Graphics
PDF Features		Tooltips, Hyperlinks
Website	Static	Mobile responsive
Customizable	None	Skin tones, Equipment colors
Number	62 + 5 Supplemental Tractor guidelines outlining cognitive, physical, etc. development	48 + 5 Supplemental Tractor guidelines outlining cognitive, physical, etc. development
Language	English +10 in Spanish	English, French, and Spanish
Supplemental Materials	Resource Manual: Job hazard analyses charts; child development checklists; training materials; and calendars	Job hazard analysis charts, checklists, bending, lifting & climbing videos, and factsheet; Supervision, communication, child development, and benefits of farm work
Booklets	Two booklets: Farm equipment, gardening	Three booklets: Farm Equipment, Gardening, Animals

Updating the guidelines started with a review of 10 tasks (e.g., driving a farm tractor, unloading grain, and bending). The Steering Committee reviewed the list and provided feedback on the topics as well as input on additional tasks young workers were engaged in on farms. Potential content consultants were solicited from the Steering Committee and Internal Team. Once confirmed, these consultants were given the original job hazard analysis framework and a checklist for a task and were asked to update its content using the latest scientific evidence. Fresh content was developed for newly added guidelines. Once completed, the job hazard analysis framework and checklist was reviewed by a child development specialist who identified developmental concerns. These materials were brought to the Steering Committee and the Internal Team to update guidelines and generate the new guidelines for topics decided upon by the Steering Committee. Examples of new topics included milking cows in a dairy parlor, operating a lawn mower, operating a utility task vehicle, operating an unmanned aerial vehicle (i.e., drone), refueling equipment, and working outdoors.

Lead by the Core Team, the Steering Committee, Internal Team, and Technical Team worked to create the format of the new resources. The decision was made to rename the North American Guidelines for Children's Agricultural Tasks to Agricultural Youth Work Guidelines (AYWG). The format of guidelines was updated to include what the youth needs to be able to do to perform the task safely, adult responsibilities, supervision, and the most common hazards and protective strategies (see Figure 3). Guidelines were hosted on a website, www.cultivatesafety.org/aywg, and available in read, print, download, and interactive forms. Each guideline displays a graphic of a person performing the task, which can be customized for skin tone (light, medium, and dark) and equipment color (red, orange, yellow, green, and blue). The online guidelines link to other relative information (e.g., connect/disconnect an implement links to a page on bending, lifting, and climbing safety) and uses tooltips to provide definitions for important terms/concepts (e.g., mature and peripheral vision). Hazards and protective strategies have visuals associated with each item listed to aid in comprehension of the dangers and how to protect oneself. All guidelines are available in English, French, and Spanish. The guidelines are available on a mobile-friendly website to enable easy access to the guidelines in multiple formats (interactive, view, print, and download) from a smartphone or tablet, thus, increasing their utility in the work setting.

Following the creation of AYWG, the Core Team developed several supplemental materials to aid in their use and dissemination. These include content on the benefits of farm work, supervision, child development, communication, and bending, lifting, and climbing. Three topic-based booklets were developed—Safety Guidelines for Youth Operating Farm Equipment, Safety Guidelines for Youth Working in Gardens, and Safety Guidelines for Youth Working with Animals. Each booklet contains 18–31 related guidelines, information on how to best use the guidelines, and related resources. The booklets are available in English, French, and Spanish in both digital and hard copy formats. A media kit was also created with guidance from the Steering Committee and shared through the website. Table 1 provides an overview of the key differences between the original guidelines and the updated version.

5. Current initiatives and next steps

The new guidelines were debuted in the opening keynote session of the 2017 International Society for Agricultural Safety and Health. Since their debut, AYWG have been and continue to be featured in numerous presentations, webinars, press releases, newsletter articles, social media posts, and other activities. Dissemination was accelerated

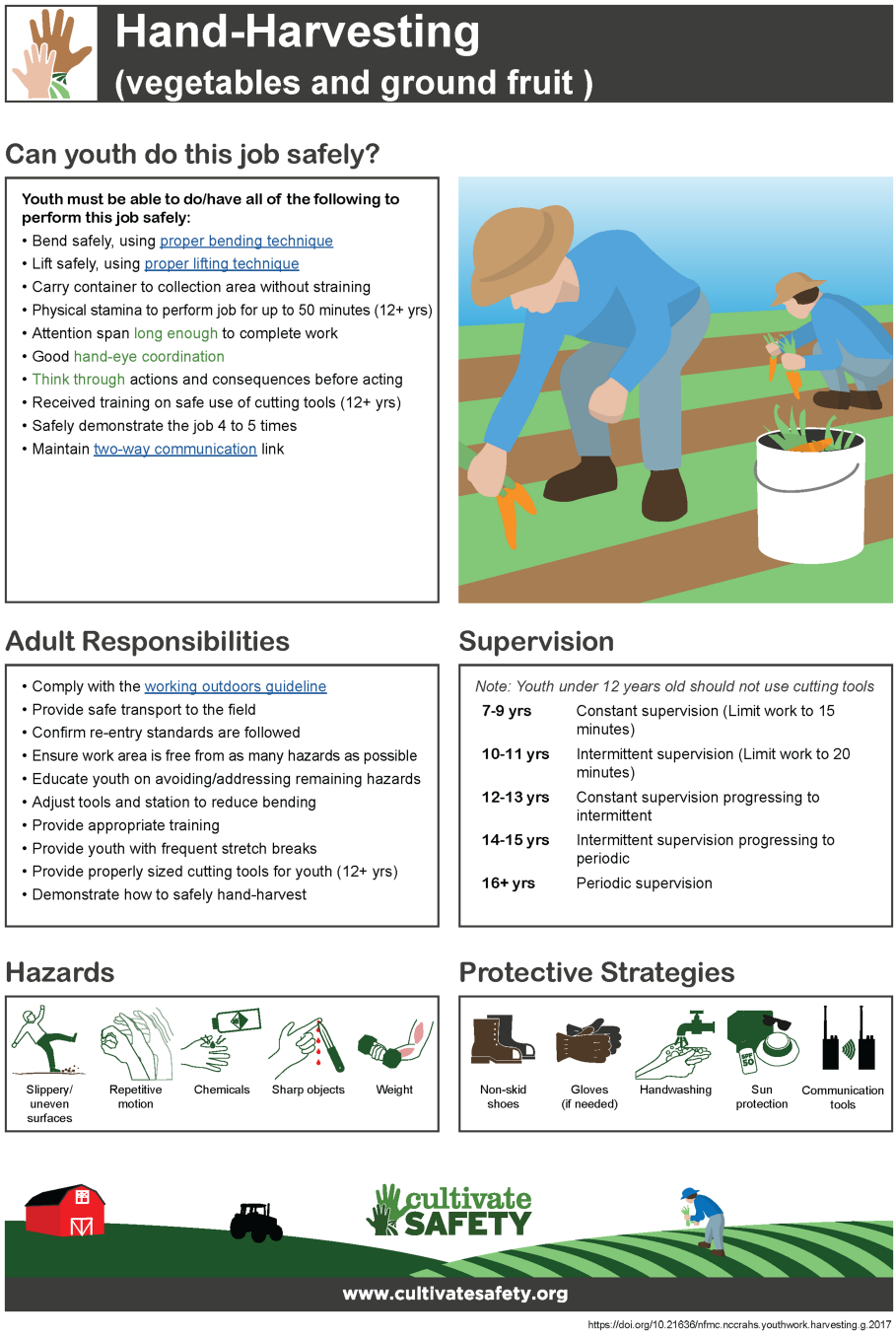

FIGURE 3
AYWG for hand-harvesting. Green text in the guideline provides pop-up definitions while blue underlined text links to supplemental materials. Published with permission from the National Children's Center for Rural and Agricultural Health and Safety.

in response to the COVID-19 pandemic. With more school-aged children present on farms due to school closings and the cancelation of extra-curricular events, organizations and media turned to the AYWG as a way to help parents keep children safe on farms. For example, the COVID-19 Interim Guidance from the Centers for Disease Control and Prevention (CDC) and the U.S. Department of Labor for Agriculture Workers and Employers provided links to the AYWG to address concerns of assignment of age-appropriate tasks to children on farms (13).

The newest initiatives involve dissemination and implementation research to guide future activities and, ultimately, increase the adoption of AYWG into practice. By incorporating evidence-based dissemination and implementation strategies, practitioners will be able to more effectively distribute materials and information to farm parents and youth supervisors to ultimately prevent agricultural injuries and fatalities in youth. Part of this process is to assess the needs of the target populations, including Latinx-owned farms and educators. Two studies currently underway investigate factors

influencing the use of AYWG among farming populations and youth educators. Findings from these studies will develop recommendations for reducing barriers and increasing motivators for using the guidelines, recommendations for messaging for organizations and end-users, and suggested modifications for future versions of AYWG.

Agricultural Youth Work Guidelines are the only known intervention aimed at reducing risk to injury and fatalities for youth working in agriculture by assessing the match between what agricultural tasks require and youth capabilities. This report describes the process of guideline generation from reconnection of a need, developing the intervention to address the need, and the process of updating the intervention. Transparency in how the guidelines were created and updated will provide researchers and practitioners valuable information as they work with guidelines and interventions in the future.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Unprotected Youth Workers in US Agriculture

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1. Introduction

Agricultural work is the most hazardous and grueling area of employment open to youth in the United States of America (US) (1–3). Farming is the only work setting where youth of all ages are legally permitted to work across all fifty states. A 2018 US Government Accountability Office study found that more than half of work-related youth fatalities occurred among youth working in agriculture (4). For most industries, the federal Fair Labor Standards Act (FLSA) sets minimum standards of protection for hired workers, which individual states can exceed if they so choose. Agriculture, however, is exempted from provisions of the FLSA due to outdated exceptions from when the FLSA was enacted in 1938 (5). As a result, youth working in US agriculture are not as legally protected as youth working in other industries.

1.1. Lax federal and state child labor laws in agriculture

For all US industries excluding agriculture, the basic minimum age for employment is 16, employment under 14 is prohibited and 14- to 15-year-old youth can only work limited hours in certain occupations (6, 7). Under federal law, hired workers under 12 years old may legally work in agriculture with no limits on hours worked per day or days worked per week (8). The FLSA agricultural exemptions permit youth working on farms to do work that the US Department of Labor has deemed "particularly hazardous … or detrimental to their health or wellbeing" at younger ages than working youth in other industries (9). Youth workers in agriculture can engage in these hazardous occupations and perform dangerous tasks at 16 years old while workers in all other industries must be 18 years old to do similarly hazardous work (6, 10). Without the legal redress afforded to all other working youth, those working on farms are not guaranteed overtime pay, leading employers to give them longer hours. These young, hired workers in agriculture experience interruptions in their education and risk serious preventable injury, illness, or death from exposure to heat, chemicals, hazardous machinery, and environmental perils, all of which can cause deleterious health effects leading to life-long, negative consequences for their health and wellbeing.

As a result of these lax federal standards, the fifty individual states have significant discretion to provide—or fail to provide—legal protections for young, hired workers in agriculture. Laws can vary from state to state, but most states' laws do not set more stringent standards than the FLSA does for young, hired workers in agriculture—and those that do are still more permissive than the FLSA is for other industries. Just a taste: 21 states permit youth of any age to work in agriculture, and age minimums in the other 29 states vary from 10 to 14 years old; 26 states set no limit on the maximum number of hours hired youth can work each day; 35 states allow hired youth to work seven days a week, while the other 15 states only require a single day off; and 23 states have no laws prohibiting hired youth from working nights. Levels and severity of enforcement vary even more between states: five states have no fines for violations, while, in the

other 45 states, fines range from $500 to $10,000; furthermore, 34 states categorize violations as criminal acts, with 32 categorizing violations as misdemeanors, i.e., a criminal offense punishable with imprisonment for up to 364 days, and only two states categorizing them more severely as felonies, i.e., criminal offenses punishable with imprisonment for 365 days or longer (11, 12) (Table 1).

1.2. Negative health consequences for young, hired workers in agriculture

US laws and policies currently governing child labor leave young hired workers in agriculture unprotected. There is no official nationwide data for children younger than 18 years old who work in agriculture. In a report released in October 2021, the Child Labor Coalition and Lawyers for Good Government estimated that, in the US, 330,000 children younger than 16 years old—including over 80,000 children younger than 10 years old—are hired workers in agriculture (12). The most recent Childhood Agricultural Injury Survey reported approximately 600,000 youth younger than 18 years old (approximately 15% younger than 10 years old, 46% between 10 and 15 years old, and 39% either 16 or 17 years old) working on farms across the US (13). In addition to educational disruption, these young agricultural workers are exposed to many occupational health risks with both short- and long-term consequences, including respiratory disease, neurotoxicity, pesticide toxicity, heat illness, musculoskeletal injuries, traumatic injuries, dermatological injuries, discrimination, and sexual harassment. Youth working on US tobacco farms incur the added risk of exposure to nicotine, a known neurotoxin. These risks are severe and widespread (13–44). Approximately 33 children are injured daily in agriculture (45). On average, one child dies in an agriculture-related incident every 3 days (2). Since 2000, young, hired workers have been killed in agriculture-related incidents in at least 49 states. From 2001 through 2015, 48% of all fatal injuries to young, hired workers occurred in agriculture (3).

But these statistics are all lower-bound estimates of the true figures. Researchers estimate that over 90% of young, hired workers in agriculture are persons of color, typically seasonal migrant Latinx. These youth often work in agricultural settings that either elude or are not subject to the surveillance and data collection procedures of the federal Bureau of Labor Statistics and the National Institute for Occupational Safety and Health; substantial numbers of young, hired workers in agriculture will therefore not be included in the best-available federally supplied data (46).

1.3. US law does not align with international standards

The outdated US agriculture child labor policy and legal regulatory framework is weak and compromising. It does not align with international labor law and global measures to protect the health and safety of children. The International Labor Organization (ILO) as well as other advocates for working children worldwide including the United Nations Children's Fund and Convention on the Rights of the Child (CRC) establish policy and sustain efforts to eradicate employment that compromises children's opportunities for good health, education, and future potential. The CRC, which the US signed, defines a child as a person under the age of 18 (47). Article 32 states that children are to be protected from economic exploitation and from work that is likely to be hazardous, to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral or social development (47). The ILO's Convention No. 138 on Minimum Ages to Employment and Work provides the normative rule of international law and defines unlawful child labor as involving any individual younger than 18 years old doing hazardous work, any individual younger than 15 years old doing any other work other than light work, or any individual younger than 13 years old doing even light work (48). This definition was expanded by ILO Convention No. 182, ratified by the US, functionally defining child labor as work that is inappropriate for a child's age, that prevents a child from benefiting from compulsory education, or that is likely to harm a child's health, safety or morals and hinder his or her development and future livelihood (49, 50). The ILO has strongly urged the US government on multiple occasions to address the gaps compromising the health and wellbeing of youth working in US agriculture (50).

2. Discussion

There is much that can and should be done to help these youth. Researchers and academics can use the methodologies of legal epidemiology—the scientific study and deployment of law as a factor in the causation, distribution and prevention of disease and injury in a population—to better inform much-needed changes in policy (51–53). By considering child labor policy and law—as well as workplace environments they create—as social determinants of health, researchers can evaluate differences between state laws regulating young, hired workers in agriculture as a potential contributing factor to health outcomes for these youth. There are large gaps, both in epidemiological data-collection and in our current understanding of the causal links between state child labor

TABLE 1 Summary of the 6 U.S. child labor law features for the 50 United States.

1. Minimum working age	21 U.S. states have no minimum age	29 U.S. states: vary from 10–14 years
2. Maximum hours per day	26 U.S. states set no limit	24 U.S. states: maximum daily hours vary by age & seasons
3. Maximum days per week	35 U.S. states allow 7 days	15 U.S. states allow 6 days
4. Prohibited night work	23 U.S. states have no laws	27 U.S. states have laws
5. Monetary fines for violation	5 U.S. states have no fines	45 U.S. states have fines ranging $500–$10,000
6. Criminal penalties for violation	16 U.S. states do not make it a crime	2 U.S. states categorize as felony, 32 categorize as misdemeanor

laws and injuries and fatalities among young, hired workers in agriculture. Filling in these gaps is crucial for effective changes in policy: policy makers will not only be better informed of the magnitude of the issue but also better positioned to implement more effective changes.

At the very least, however, the outdated agricultural loopholes in the FLSA must be closed. At the federal level, the proposed Children's Act for Responsible Employment, also known as the CARE Act, would do just that: among other things, it would raise the minimum age for especially hazardous work from 16 to 18 years old and prohibit any agricultural work, except on family farms, by anyone younger than 14 years old (53–59). The CARE Act was originally proposed in Congress in 2009 and, despite being reintroduced several times, it has regrettably still not been passed (54–60). Another important legislative attempt to target US tobacco farms specifically is the Children Don't Belong on Tobacco Farms Act, which would prohibit employment of youth younger than 18 years old in tobacco-related agriculture. The bill was first introduced in Congress in 2015 and, though it has also been repeatedly reintroduced, has not been passed (61). But states do not need to wait for Congress to act—they can change their own laws at any time to bring child labor protections for agriculture in line with those for other industries. Whether change comes from the federal level or individual states, it is clear that change is needed. Young hired workers in agriculture are among the most vulnerable and marginalized populations in the US, and they are in dire need of legal protection.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Recruiting farm parents for a 6-week online child safety survey study using paid Facebook advertisements

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Agricultural populations are a popular target for research due to the industry's dangerous conditions, unique work environments, and youth-including workforce. However, reaching and recruiting eligible participants is challenging and expensive when compared to other industries. We conducted a two-phase, multi-week paid advertising campaign on Facebook.com, varying delivery time, imagery, verbiage, and targeting methods to recruit U.S. farm parents for an online survey study investigating childhood agricultural safety. Advertisements were active for 4 weeks in fall 2021 and 3 weeks in winter 2022 at $1,500 per week. The fall recruitment targeted farm parents, depicting three farm-related images, while the winter recruitment targeted all parents, depicting farm-rescue trainings with firefighters. The fall recruitment garnered 5,535 link clicks with a reach of 233,690 ($1.07 per click). The winter recruitment garnered 8,602 clicks with a reach of 750,764 ($0.53 per click) and higher user engagement. A total of 1,439 participants began the screener questionnaire, a conversion rate of 10.18%. Of 815 completed responses, 271 met our inclusion criteria. One hundred and sixty-four participants completed the study: 45 from fall (27.6% dropout) and 119 (40% dropout) from winter. The overall attrition rate was 38.1% and cost per completed response was $64 USD. We successfully recruited our target sample size for this study. Notably, advertisement timing, imagery, and sampling frame likely affected performance. A screening questionnaire was imperative in identifying sham responses. These findings show that paid Facebook advertising can be a feasible recruitment tool to engage with a traditionally difficult to reach population with proper precautions and planning.

KEYWORDS

Facebook, recruitment, farm, parents, child, injury, prevention, agricultural safety

1. Introduction

Agricultural populations are a popular target for research due to the industry's dangerous conditions, unique work environments, and youth-including workforce (Nilsson, 2016; US Bureau of Labor Statistics, 2021; National Children's Center for Rural Agricultural Health Safety, 2022). However, reaching and recruiting eligible participants is often challenging, time-consuming, and expensive when compared to other industries and populations (Glas et al., 2019; Turland and Slade, 2020; Weigel et al., 2021). Traditionally, contact information would be acquired or purchased from data vendors, extension agencies, or government

agencies, and then participants randomly selected, or random digit dialing is conducted for broader scopes. However, these can often be expensive and introduce unique biases as cultural changes affect traditional recruitment methods (Couper, 2017). For example, Pew Research reports a 27% point decrease in phone telephone response rates from 1997 to 2016 (Keeter et al., 2017). Similarly, address-based sampling, often acquired through the US Postal Service's Delivery Sequence File, can provide a large number of potential participants with high accuracy, but can require time and labor intensive eligibility verification (Iannacchione et al., 2003).

Historically, phone and physical address-based recruitment methods have been used and evaluated for agricultural populations (Glas et al., 2019; Weigel et al., 2021). However, a notable challenge for these populations is identifying eligible participants from a larger sample. Several private and public agencies exist which house these specific datasets, but this introduces additional cost, time, and regulatory oversight. As such, in order to account for changing population habits and recruitment efficacies, social media (e.g., Facebook and Twitter) has been increasingly used to recruit large and diverse groups, demonstrating it's potential to be a useful and cost-effective recruitment tool for research (Ramo and Prochaska, 2012; Frandsen et al., 2016; Jones and Salazar, 2016; Lee et al., 2020).

Home to both Facebook and Instagram, parent company Meta is the largest social media company operating today. Facebook.com reports over 1.8 billion active users-—200 million within the US—and is trending upwards as more Americans use the internet (Pew Research Center Internet Technology, 2019; Facebook, 2022). Facebook provides tools for targeting unique and traditionally hard to reach populations based on data provided by individuals and gathered by monitoring users' activities on the platform. The integrated ads manager platform within Facebook.com allows for targeting based on interests, industry, demographics, etc. which help alleviate the labor intensive process of creating the sampling frame. While the accuracy of this labeling has been called into question (Jones et al., 2012), this remains a popular tool for improving advertisement accuracy and cost efficiency (Schneider and Harknett, 2022).

Despite this, there is little evidence regarding social media's effectiveness in recruiting agricultural populations. As rural areas of the US gain internet access, it is likely online methodologies for recruiting and researching these populations also increase, as seen in telemedicine and remote work opportunities exacerbated by the COVID-19 pandemic (Perrin, 2019; Hirko et al., 2020; Rush et al., 2021).

This study employed an expansion of duration and budget, from a past pilot test through Facebook.com paid advertisements (Burke et al., 2021). In this paper, we describe our two-phase, multi-week paid advertising campaign on Facebook.com, varying delivery time, imagery, verbiage, and targeting methods to recruit U.S. farm parents for an online survey study investigating childhood agricultural safety.

2. Methods

We ran a two-phase paid advertisement campaign on Facebook.com, via the Meta Business Suite, from Sep 27, 2021 to October 21, 2021 and from Jan 27, 2022 to Feb 17, 2022, hosted on the Facebook page for the National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS). The first, fall phase was targeted toward parents aged 18 and above with employment in the "Farming, Fishing, and Forestry" industry as defined by Facebook as "People with roles in farming, fishing and forestry. Examples include: farmer, rider, crew member, handyman, etc." with an estimated user population of 2,000,000. The second, winter phase was targeted toward all parents nationwide, farm and otherwise, aged 18 and above as defined by Facebook with an estimated population of 200,000,000. Both phases were targeted to individuals within the US.

The fall phase included three images: a child feeding a calf with a bottle, a girl sweeping a barn in full personal protective equipment, and an overturned tractor (Figures 1A–C), advertised concurrently. The winter phase instead included two images of a night-time firefighter training, one featuring an overturned tractor for weeks 1 and 2 and one featuring a grain bin for weeks 3 and 4 (Figures 2A, B, respectively; week 4 was not conducted as the target recruitment number was reached). Both phases included verbiage such as "Farm parents wanted!" and "See if you're eligible for on online, paid survey study." Both phases were budgeted at $6,000 USD each charged per-click.

All advertisement clicks led to a REDCap-hosted consent form followed by a brief 10-item screener questionnaire asking participants about farm and family demographics, alongside a description of the full research study. Participants were compensated $50 USD for full completion of the study, informed during consent. Participants were then invited to the full study on a weekly rolling basis pending manual review of screener response integrity, such as identifying non-sensical farm demographic responses (e.g., reported a beef operation with no cattle). This study consisted of a pre- and post-test survey measuring knowledge, attitudes, and intended behaviors toward childhood agricultural safety. Experimental and control group participants were randomly assigned to read through 4 weekly news articles on a childhood agricultural injury incident or non-health and safety-focused farm life articles, respectively. The reading of articles occurred between the pre- and post-tests.

All advertisements were closely monitored by our research team for community engagement and public comment. Derogatory comments were hidden (visible only to the poster and their Facebook friends). Meanwhile, public questions and comments were responded to by our team, through the NCCRAHS Page, where appropriate. The winter phase was terminated after 3 weeks and $4,627 spent as we reached our target study enrollment of 200 participants and at least 160 completed responses. Throughout the campaign, ad performance was monitored for engagement, reach, impressions, clicks, click-through-rate, survey throughput, and attrition rates.

3. Results

3.1. Advertisement performance

The fall phase was completed at a total cost of $5,944 and the winter phase at $4,627. The fall phase saw 23 shares, 137 reactions, and 27 comments with most being neutral or an inquiry for more

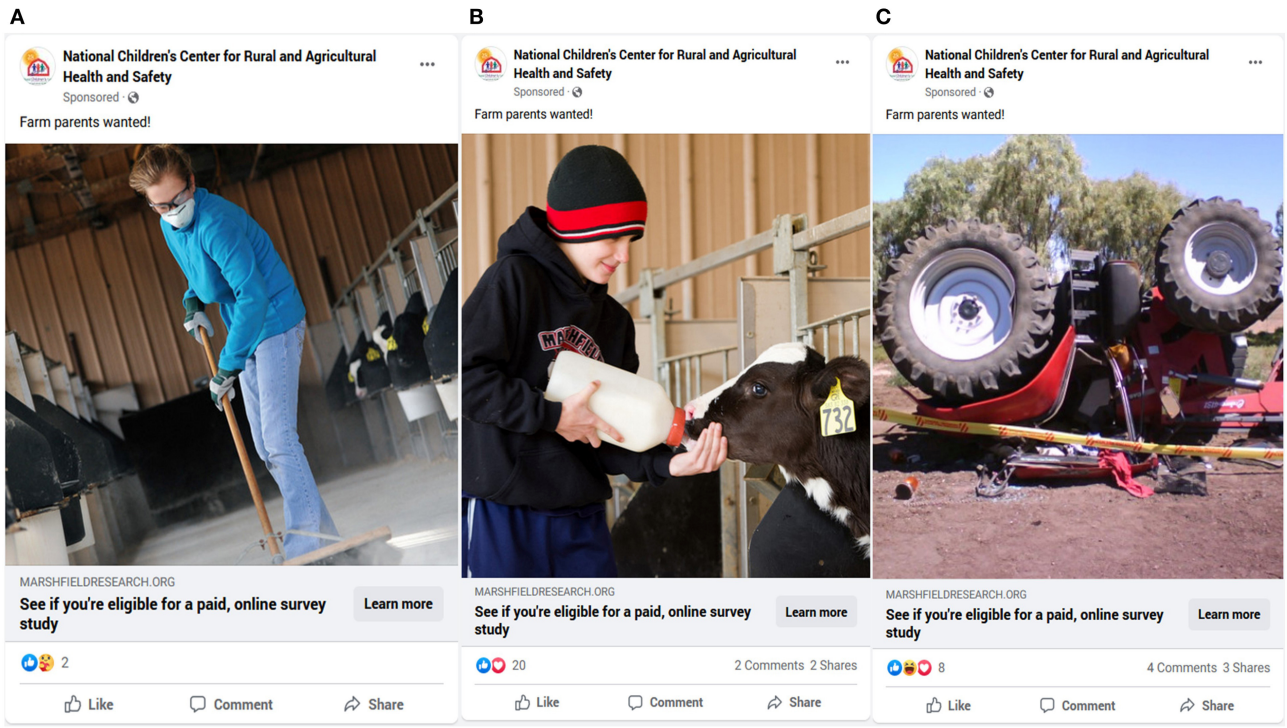

FIGURE 1
Fall campaign advertisements depicting a girl sweeping in full personal protective equipment **(A)**, a child feeding a calf **(B)**, and an overturned tractor **(C)**.

information (Table 1). This phase saw 5,535 clicks leading to 113 partial screener completions and 243 full completions (Figure 3). Of these, 76 were determined to be eligible for the full study and were invited, 45 of whom completed the full survey study. This yielded a cost per click of $1.07 with a cost per completed response of $132.

Images of the girl sweeping and the child feeding the calf (Figures 1A, B, respectively) performed similarly, however the tractor rollover image (Figure 1C) yielded much better results with nearly double the combined reach, impressions, and clicks of the other two images. Notably, due to the tractor image's success, we reallocated all designated advertisement funding to only this image for week four. Prior to week four, the tractor image had similar cost per click to the other images.

The winter phase garnered much greater engagement and performance metrics with 91 shares, 196 reactions, and 52 comments (Table 1). This phase saw 8,719 clicks leading to 221 partial screener completions and 574 full completions (Figure 3). Of these, 195 were determined to be eligible for the full study and invited, 119 of whom completed the full survey study. This yielded a cost per click of $0.53 and a cost per completed response of $36, in line with other research studies. However, this phase saw a greater number of derogatory and inflammatory comments with three requiring immediate moderation, compared to zero in the fall phase. We also observed a more in-depth discussion among commenters, sharing personal stories of farm injuries and firefighters responding to calls on farms, including an 18 comment-long dialogue.

The two winter phase images performed similarly. While the tractor image garnered greater engagement with commenters, both had similar levels of reach, impressions, and clicks.

Overall, this 7-week advertising campaign saw a reach of 1,050,348, with 1,938,026 impressions, and 14,254 clicks at $0.74 per click; we had 79 comments, 114 shares, and 332 reactions. Not accounting for personnel time, our advertisement yielded a cost per participant of $36 and a cost per completed response of $64. We did not see any geographic biases in respondents' locations.

3.2. Post-advertisement behavior

With 14,254 link clicks and 817 completed screener questionnaires, we observed a conversion rate of 5.7%. We invited 271 eligible participants to the full study, 265 of whom consented to the pre-test questionnaire. Of these, 164 completed the full study, yielding an overall attrition rate of 38.1% and a dropout rate of 39.5%, greater than our predicted 30%. The fall campaign showed a lower dropout rate than the winter campaign at 27.6 and 40%, respectively, though with markedly fewer participants.

Notably, during the winter campaign, we observed 106 responses to the screener questionnaire completed within 90 min, compared to the average of 4.9 h between all other screener completions. Further investigation found these to be mostly non-sense responses, including participants who reported dairy operations with no animals or equipment present. These responses were deemed fraudulent and ineligible for full study enrollment.

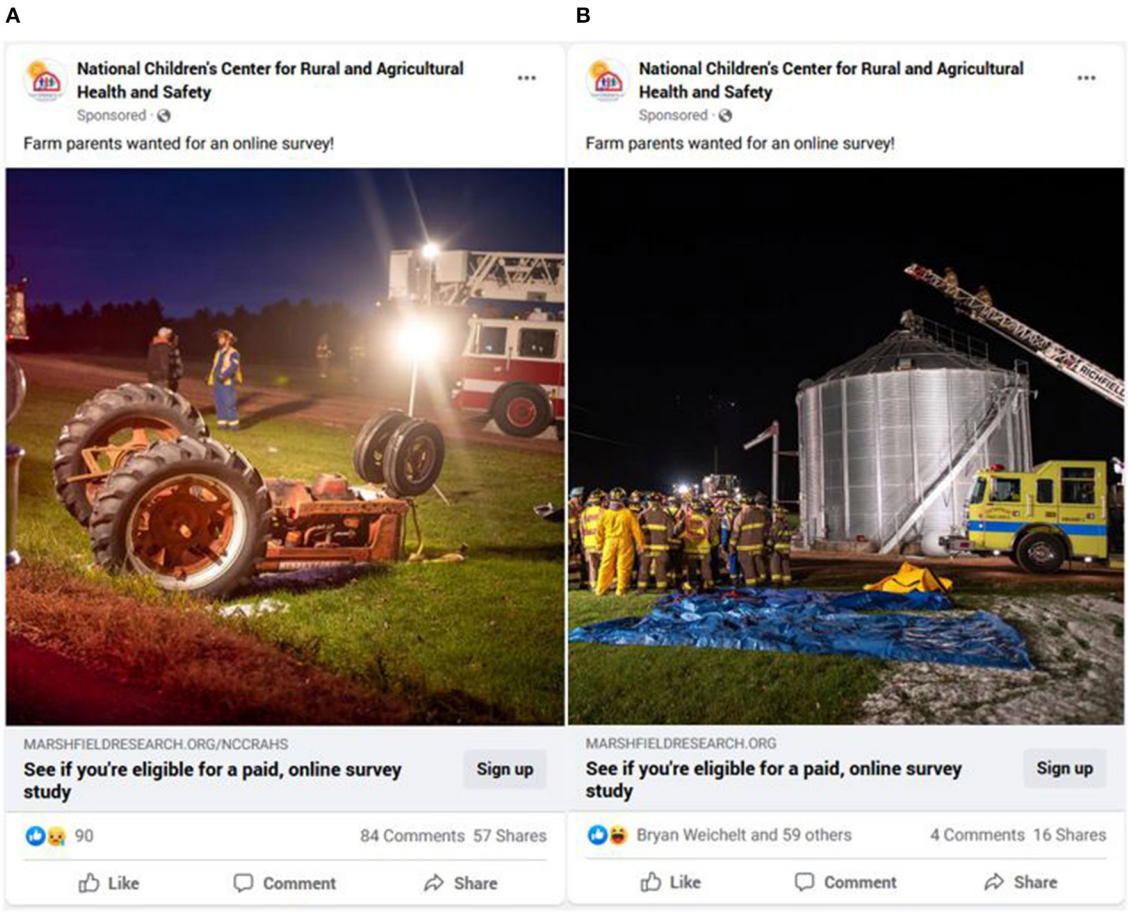

FIGURE 2
Winter campaign advertisements depicting a firefighter training of an overturned tractor **(A)** and a grain bin rescue **(B)**.

4. Discussion

This study has demonstrated that paid advertisements on Facebook.com can be an option for recruiting a farming population for online survey studies or similar long-term surveys. We were successful in recruiting a sufficient number of participants for a 6-week online survey study, however the cost was generally high at $36 USD per eligible participant and $64 per completed response. We also observed relatively high attrition rates of 38% throughout the study. However, the costs and dropout rates can be managed with proper preparation and forethought such as enticing but reasonable incentives, personal attachment/emotional components to study messaging, and balancing study safeguards with ease of participation.

4.1. Performance differences

We observed a notable difference in performance and efficiency between our two advertising phases. Our winter phase saw nearly triple the eligible participants at nearly 1/3 the cost per completed response and half the cost per click. The three main differences we believe contributed to the success of the winter campaign over the fall are the timing, imagery, and sampling frame. The first campaign was conducted during fall—harvest and back-to-school season—while the second took place during the typically slower winter season. The additional free time of farm parents allows for greater time spent on social media and greater willingness to participate in surveys.

We also leveraged the performance of the initial ad campaign to select more eye-catching pictures for the winter phase. The first phase was split into three categories based on a safety survey: a high safety adoption image (Figure 1A, girl sweeping in full protective equipment), a neutral image (Figure 1B, child feeding a calf) and a low safety adoption image (Figure 1C, overturned tractor). Given the success of the tractor image, we selected a similar image with the focus on firefighters due to their close ties to the farming population and their role in public health and safety (Figure 2). The wording on all images remained similar throughout the study.

Lastly, the major difference in the sampling frame chosen (2,000,000 parents employed in Farming, Fishing, and Forestry vs. 200,000,000 parents in total) may have impacted performance. The frequency of ads shown to an individual person in the fall campaign was 3.6 vs. 1.55 in the winter campaign. The greater number of impressions and individuals who viewed the winter campaign

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TABLE 1 Advertisement performance analytics by campaign, week, and image.

Week 1	Reach	Impression	Clicks	Cost per click ($)	Comments	Reactions	Shares
Sweeping	17,184	37,785	230	1.18	0	2	0
Child	14,688	43,944	204	1.64	2	18	2
Tractor	37,703	116,113	603	1.48	5	8	6
Week 2							
Sweeping	18,005	48,992	206	1.87	0	0	0
Child	17,723	62,053	240	2.03	0	10	2
Tractor	31,599	83,263	376	1.67	1	2	1
Week 3							
Sweeping	12,710	28,646	159	1.39	0	6	0
Child	17,090	57,442	217	1.72	0	5	0
Tractor	41,894	124,254	559	1.62	1	9	1
Week 4							
Sweeping	2,180	2,361	14	1.52	0	0	0
Child	1,637	2,043	11	1.39	1	6	0
Tractor	87,070	169,722	2,716	0.52	17	70	11
Weeks 1–3							
Sweeping	47,899	115,423	595	1.48	0	8	0
Child	49,501	163,439	661	1.81	2	33	4
Tractor	111,196	323,630	1,538	1.58	7	19	8
Fall total							
Sweeping	50,079	117,784	609	1.48	0	8	0
Child	51,138	165,482	672	1.80	3	39	4
Tractor	198,266	493,352	4,254	0.90	24	89	19
All	299,483	776,618	5,535	1.07	27	136	23
Week 5							
Tractor	255,123	424,071	3,454	0.48	35	88	48
Week 6							
Tractor	263,378	402,261	2,588	0.58	15	50	27
Week 7							
Grain bin	232,364	335,076	2,677	0.55	2	58	16
Winter total							
Tractor	518,501	826,332	6,042	0.52	50	138	75
Grain bin	232,364	335,076	2,677	0.55	2	58	16
All	750,865	1,161,408	8,719	0.53	52	196	91
Total	1,050,348	1,938,026	14,254	0.74	79	332	114

likely gave a greater chance for willing and eligible participants to respond, as noted by the higher click rate though lower proportion of eligible participants among conversions. While we observed a lower portion of eligible completions of our screener tool, the winter campaign still yielded more cost-effective recruitment. These changes were made in order to increase recruitment first and foremost, making a direct comparison between campaigns difficult and inaccurate. Yet, these findings and experiences lend themselves to inform and direct future recruitment of agricultural populations.

4.2. Spam responses

Given the broad reach and mass-viewing that paid advertisements can garner, a filter between the advertised

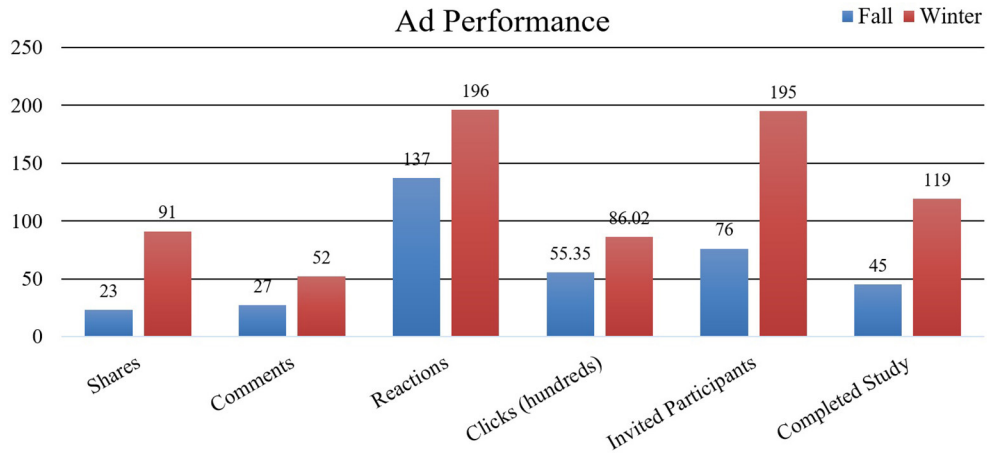

FIGURE 3
Comparison of fall and winter campaign metrics.

survey and the public was imperative. The mention of a paid survey opportunity is a double-edged sword: it can catalyze scammers and those looking to take advantage of the survey but it also encourages the target population to inquire, incentivizing research participation. Creating a stop-gap in participant workflow, that is, a filter for manual review of response integrity, allowed us to identify and remove over 100 fraudulent responses saving time and effort of doing so after participants have completed the full study and received incentives. However, this likely reduced our survey's conversion rate and recruitment rate as participants had an additional barrier between them and the survey study.

4.3. Comment moderation and engagement

Public advertisements with open forum community engagement yielded another avenue for benefits and drawbacks. A higher number of comments and shares can increase reach and impressions on an advertisement, showing the study to additional prospective participants without an increase in advertising costs. Presumably, these comments led to an organic spread of the advertisement into the commenters' networks, displaying on the news feeds of their network connections. However, the openness of the ads allows for bad-faith actors and inflammatory comments to affect the legitimacy of the ad, the hosting Facebook page, and any affiliated organizations.

We observed multiple comments questioning the veracity of the study, and some denouncing agricultural health and safety as regulatory overreach and child endangerment. While Facebook provides the option to hide or delete these comments, this requires a project team to be moderating the ad outside normal working hours, and the attempted controls could lead to further inflammatory responses when a comment is censored. The necessary staffing is an important consideration for research teams contemplating taking on this type of recruitment strategy. The sampling frame is also an important aspect, as the narrower targeting of just AFF occupations in the fall campaign resulted in no publicly posted comments requiring our team's immediate action. We recommend careful consideration, pre-planning, and maintaining an open dialogue with the host Page's administrative/communications team prior to initiating paid advertisement recruitment on a social media platform.

Contrary to this, increased engagement can also provide a benefit to the affiliated pages and organizations. We observed an 18-comment dialogue between farmers, firefighters, and our staff members promoting agricultural health and safety. We also saw a slight increase to the NCCRAHS Facebook Page performance analytics, and new followers of the page.

5. Conclusions

This study has shown that using paid Facebook advertisements to recruit farm parents for a long-term, online survey study is feasible with the proper precautions in place. These advertisements can introduce various uncertainties, biases, and costs not experienced with traditional recruitment methods. Screener forms, moderation teams, and careful wording/image selection can help alleviate these drawbacks in order to reach a historically difficult to recruit population.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Marshfield Clinic Research Institute Institutional Review Board. The patients/participants provided their written informed consent to participate in this study. Written informed

consent was obtained from the individual(s) for the publication of any identifiable images or data included in this article.

Author contributions

RB: study design, survey creation and management, Facebook advertisement creation, management and data collection, data preparation and analysis, and manuscript preparation. BW: study design, survey creation, Facebook advertisement creation and management, data analyses and interpretation, and manuscript preparation. KN: study design, survey creation, data analyses and interpretation, and manuscript preparation. MP: advisement of study design, Facebook advertisement creation and management, and manuscript preparation. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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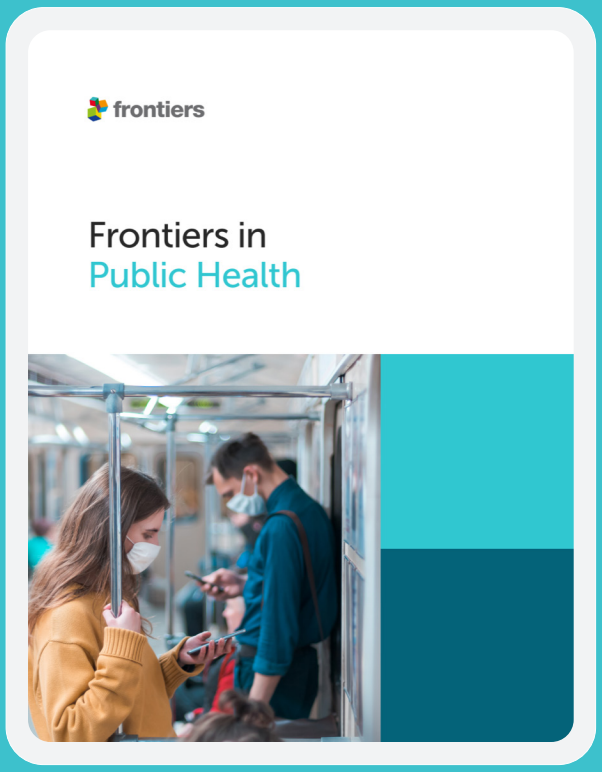

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