ONE HEALTH, ENVIRONMENTAL HEALTH, GLOBAL HEALTH, AND INCLUSIVE GOVERNANCE: WHAT CAN WE DO?

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PUBLISHED IN: Frontiers in Public Health

frontiers Research Topics

ISSN 1664-8714
ISBN 978-2-88976-997-1
DOI 10.3389/978-2-88976-997-1

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Citation: Laaser, U., Bjegovic-Mikanovic, V., Seifman, R., Senkubuge, F., Stamenkovic, Z., eds. (2022). One Health, Environmental Health, Global Health, and Inclusive Governance: What can we do? Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88976-997-1

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frontiers | Frontiers in Public Health

TYPE Editorial
PUBLISHED 05 August 2022
DOI 10.3389/fpubh.2022.932922

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Environmental health and Exposome, a section of the journal Frontiers in Public Health

RECEIVED 30 April 2022
ACCEPTED 03 June 2022
PUBLISHED 05 August 2022

CITATION
Laaser U, Bjegovic-Mikanovic V, Seifman R, Senkubuge F and Stamenkovic Z (2022) Editorial: One health, environmental health, global health, and inclusive governance: What can we do?
Front. Public Health 10:932922.
doi: 10.3389/fpubh.2022.932922

Editorial: One health, environmental health, global health, and inclusive governance: What can we do?

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KEYWORDS

One Health, environmental health, global health, inclusive governance, bottom-up, top-down

Editorial on the Research Topic
One health, environmental health, global health, and inclusive governance: What can we do?

"One Health" is a broad conceptual platform that encompasses a global view of human and animal health, along with the environment, encompassing air, water, soil, and plants. It requires integrating interactions both from bottom-up and top-down perspectives, anchored in an inclusive government (1) and supported by interactive science, i.e., scientific cooperation across disciplines. At the ground level, what is done in practice must influence those governing, leading to more responsive, effective, and inclusive governance and in so doing, much-improved outcomes. Human and veterinary medicine, public health, social sciences, educators, and legislators have to be involved and contribute to what is decided and done at the national and local levels.

An integral element of the One Health concept is the critical importance of addressing the effects of the devastating environmental imbalance of today. This is a major task for our generation and our children, with very limited time left to avoid a planetary catastrophe, aspects of which are already visible. Worldwide, and in many regions and individual countries, current economic, social, and environmental policies are too dangerous and unsustainable. The future state of the environment is, in short, central to One Health's aspirations. The imbalances between developing and developed countries are crucial aspects of this, with many examples that demonstrate this point. For example in this research volume, Streichert et al. discuss the pandemic response, outlining that "lack of opportunities is a commonly reported barrier to involvement

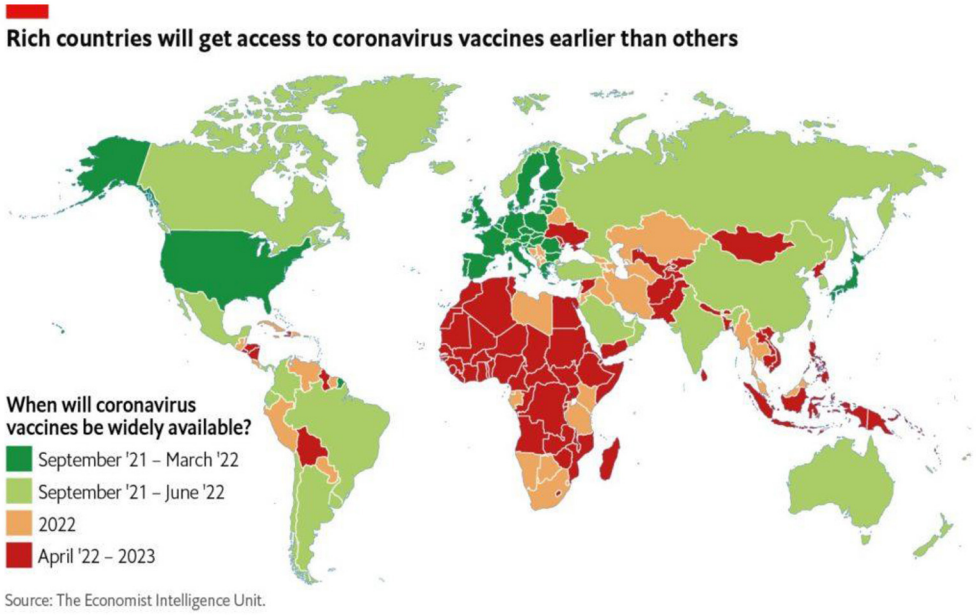

FIGURE 1
When will coronavirus vaccines be widely available? Source: The Economist Intelligence Unit.

globally, with lack of funding the largest barrier in the WHO African region." Eliakimu and Mans promote the concept of inclusive governance to cope with global inequalities. Differences in COVID-19 vaccine availability showcase the challenge (Figure 1)[1]:

The basic framework for One Health research is captured in THE WORLD IN 2050 INITIATIVE (TWI) (2), which defines six sustainable development pathways:

(1) Education, gender, and inequality.
(2) Health, well-being, and demography.
(3) Energy de-carbonization and sustainable industry.
(4) Sustainable food, land, water, and oceans.
(5) Sustainable cities and communities.
(6) Digital revolution for sustainable development.

These six areas provide the broad framework for the contributions within this Frontiers for Public Health Research Topic. The contributions can be further divided into four groups, of which there are 11 articles published to date.

The *first* group comprises more familiar topics including tobacco control policies in the Indonesian mining industry (Prabandari et al.). Another article in this grouping explores one health perspective regarding diarrhea in Pakistan (Abbasi et al.) while another discusses the quality of life connected with living near a solid waste facility (Phan et al.).

The *second* group deals with the *COVID*-19 pandemic, such as a paper on variations of COVID-19 in the three Palestinian territories, the West-Bank, East-Jerusalem, and Gaza Strip (Abed et al.), covering the spread, risk factors, and interventions. Mahadi discusses the post-COVID AMR threat in LMIC, taking Bangladesh as an example. Another analyses participation in One Health networks as part of a COVID-19 response (Streichert et al.).

The third group covers information and policies. Coming from the same background as Streichert et al., i.e., the One Health Commission, Eliakimu and Mans review inequalities toward inclusive governance. Roopnarine et al. discuss the missing professional perspective of One Health for medical, veterinary, and public health students. LeBlanc et al. underline bioethics and One Health to build reflexive governance. Finally, Yu et al. analyze the effects of environmental information on elderly people in China.

The fourth area deals with satisfaction in life, which is often integrated under the Subjective Well-being (SWB) rubric, as documented here for three countries in the Western Balkans: Montenegro, North Macedonia, and Serbia by Bjegovic-Mikanovic et al. As outlined in this study, Montenegro takes a top position in almost all dimensions.

To achieve significant One Health breakthroughs, there must be diminishing global economic and social disparities between countries and within countries. Even in the most

1 https://www.eiu.com/n/rich-countries-will-get-access-to-coronavirus-vaccines-earlier-than-others/

developed countries, underserved populations are substantial in numbers. Their lot has to be improved if we want to follow a civil discourse, both within countries and between them, and at global levels. The unfortunate reality is exemplified during these last two pandemic years by the case of vaccine availability and supporters attacked by the anti-vax movement.

The question remains, can we expect those without power and those who are being deprived to behave according to One Health approaches? In most societies, waiting in the wings, and not being able to access essential services can result in aggressive communication or even physical attack. There are differences, of course, inherent in culture to not tolerate such conduct, such as in the Scandinavian countries. In many other countries and may be in Scandinavia as well, there are risks that a pandemic like that of COVID-19 and its restrictions will continue to unlock latent resentment and anger of those less fortunate. The many implications of largely unregulated social media make it easier to develop extremist views that grow fast in times of general hardship when people look desperately for information and support, and unfortunately often encounter facile answers (3).

Addressing the fundamental question of what we can do at this time to save future generations, the following four areas can contribute to our social and scientific environments (4, 5):

(1) Identify the barriers to changing unsustainable behaviors.
(2) Employ various commitment strategies.
(3) Produce and communicate effective messages.
(4) Enhance motivation and invite participation (active civility).

Despite the promise of these strategies, limitations are also evident. The present trajectories cannot be redirected by the global North alone; effective international cooperation will be of central relevance. Physicians and veterinarians are essential professions that likewise cannot change the presently prevailing trends alone, and contributions from the social and political sciences are vital for implementing change successfully. In summary, the space between bottom-up and top-down, between grassroots and organized action needs to be filled by all of us. To progress toward One Health, it will not be enough to organize the *Connected*: we must also proactively engage impoverished and marginalized *Disconnected* populations (3) to negotiate dangerous times and unpredictable futures.

Author contributions

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

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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frontiers in Public Health

ORIGINAL RESEARCH
published: 15 July 2021
doi: 10.3389/fpubh.2021.704791

The Missing Professional Perspective: Medical, Veterinary, and Dual Degree Public Health Student Perceptions of One Health

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Introduction: One Health (OH) is an important concept to design appropriate public health responses to emerging diseases such as COVID-19. How trainee health professionals understand this concept is important to its implementation. In this study, we explored how medical (MD), veterinary (DVM), and dual degree MD and DVM Master of Public Health (MPH) students define OH and its relevance to practice.

Methods: Students participated in a survey that included the Readiness for Interprofessional Learning Scale (RIPLS), and two questions requiring them to define and explain the relevance of OH. The transcripts of the OH responses underwent thematic analysis. Role theory was used to explain the variation in how students from these different programmes viewed the concept.

Results: The responses of the MD and DVM students in contrast to the dual degree MPH students reflected gaps in their understanding of the concept that pertained to the specific health impacts of global warming; antimicrobial resistance, food security; social, cultural and environmental determinants of zoonoses occurrence, and health policy formation.

Discussion: Mitigation of the global risks to public health require a collaborative approach by health professionals. Our findings suggest that MD and DVM students are unaware of many factors that impact patient health outside of their own discipline. The inclusion of dual degree students revealed novel insights that undertaking an MPH may have enabled them to be more aware about the interdisciplinary relevance of OH to their professional practice. We recommend that structured incorporation of OH should inform future medical and veterinary curricula.

Keywords: One Health, role theory, medical, veterinary, dual degree, COVID-19, public health

OPEN ACCESS

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Specialty section:
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

Received: *05 May 2021*
Accepted: *16 June 2021*
Published: *15 July 2021*

Citation:
Roopnarine R, Boeren E and Regan J-A (2021) The Missing Professional Perspective: Medical, Veterinary, and Dual Degree Public Health Student Perceptions of One Health. Front. Public Health 9:704791. doi: 10.3389/fpubh.2021.704791

INTRODUCTION

The emergence of the COVID-19 pandemic has highlighted the importance of public health preparedness for mitigating its spread. Increasingly, the current threats to global health posed by antimicrobial resistance, the environmental impacts of climate change, food security, and the emergence of zoonoses such as Ebola and COVID-19, remind us of the interconnection

between animal, human, and environmental health. This need for interdisciplinary work within and between the health professions is embodied by the conceptual framework of One Health (OH) (1). Traditionally, interprofessional learning has focused on the shared learning that occurs between students from medicine and the allied human health disciplines, typically excluding veterinarians (2). In an increasingly globalized world, OH—with its public health orientation and embrace of the animal-human-environmental health connection, provides a much needed transdisciplinary framework to address current emerging threats. Settele et al. (3) suggest that OH can facilitate interprofessional collaboration in framing health policy changes that seek to protect the natural environment. Furthermore, Marty and Jones (4) argue the OH framework enables an interdisciplinary approach to be applied to conducting the surveillance necessary in animals, humans and the environment, to identify the likely sources of pandemics such as SARS- CoV-2. This collaborative approach is also important in light of global policy pressures directed by the United Nations as part of its Sustainable Development Goals (5) with a focus on preventing hunger by addressing the issues of food security and climate change.

Successful execution of the OH approach by health professionals requires that they are knowledgeable about the concept. Interprofessional learning has been advocated as a pedagogical tool for enabling the application of the principles of OH to practice, given its core focus on developing competent team workers with excellent communication skills (6). Chapman and Gupta (7) as well as Steele et al. (8) argue that it is crucial for medical students to be familiarized with the principles of OH that connect human, animal, and environmental health to prepare them for their future roles in addressing global health issues, as well as for managing zoonotic infections in their patients. In the same vein, others (9) expressed concerns about the absence of content on ecosystem health within the veterinary curriculum. For example, Lorusso et al. (10) discussed that emerging zoonoses such as COVID-19 indicate that competencies in genomics, social sciences and data management are critical for inclusion within the curriculum for the future veterinarian to actively participate as frontline responders in a public health response. Maeshiro et al. (11) discussed that these competencies also need to be developed as part of the core medical curricula. This is important to avert the gaps in public health preparedness exhibited by the medical fraternity during COVID-19, specifically a lack of focus on preventive medicine, testing and the impact of social disparities on pandemic mortalities.

Within the literature on the need for the introduction of OH in medical curricula, Chapman and Veras (12) discuss that health professional students need to be able to link issues such as antimicrobial resistance, zoonoses and climate change to OH, so that future practitioners have the competencies to address these issues as part of their professional duty to safeguard the population's health. Chapman and Animahasun (13), both medical doctors, also discuss the need for MD students to be exposed to OH early on in their training. This will better prepare them to consider a more holistic approach to arriving at a diagnosis, to communicate health issues with their patients, and to consider the impact of animal and environmental health factors on patient health. Animasahun et al. (14) also discussed that MD students' familiarization with the principles of OH is crucial for their involvement in driving policy change, positively altering human behaviors that negatively impact the environment. For example, they discuss that MD students can use modern technology and social media to educate communities on environmental issues such as the impact of fossil fuels usage on respiratory health and implementing measures to reduce mosquito exposures that lead to vector borne disease emergence.

Decaro et al. (15) discuss that veterinarians with their experience of developing biologics for animal corona viruses can assist future research to develop effective vaccines and antivirals in human medicine for SARS-CoV-2. Similarly, veterinarians should perceive their role in driving policy changes that require animals be kept in hygienic and well-managed market facilities, to mitigate the risk of viral spillover into humans (15). Veterinarians are in a position to drive the OH movement forwards by driving policy changes that mitigate against human invasion of the environmental habitats of wild animals, that contribute to spill-over of diseases from humans to animals. Gibbs and Gibbs (16) also provide excellent examples that portray the role of veterinarians in considering the impacts of ecological health on human and animal health as axiomatic. For example, the effects of use of diclofenac to treat Indian cattle and its devastating effects on decimating scavenging vulture populations had huge implications for ecological health. Human destruction of bat habitats was responsible for the emergence of Nipah virus through human consumption of the amplifier porcine hosts in Malaysia. Gibbs and Gibbs (16) are clear that for these reasons, the North American Veterinary Medical Consortium (NAVMEC) recommend OH knowledge as a key professional competency for veterinarians, and yet it is not an accreditation requirement for medical or veterinary curricula.

The literature to date has in a few instances explored the positive experiences that OH educational interventions have had on MD and DVM students but *not* the students' understanding of OH which is crucial for its execution (17, 18). As we sought to determine how MD and DVM students view the concept of OH, our research question was:

> *How do students of the Medical (MD), veterinary (DVM) and dual degree Master of Public Health (MPH) students define the framework of One Health (OH) and its relevance in preparing them for health practice in the global environment?*

The comparison between these groups of students is important as they tend to perceive their future professional roles differently. These students' readiness for interprofessional learning varies according to their perceived roles in the future. Research by the authors of this paper has confirmed that students in a dual degree programme, combining a MD or DVM programme with an MPH are more open to collaborative learning than those who take a stand-alone programme (19). Although, the content pertaining to aspects of OH may vary across MPH curricula at various institutions, MPH students, in contrast to MD and DVM students, are expected to apply their

TABLE 1 | MD, DVM, and MPH curricula comparisons: credit hours for One Health topics.

MD courses	Credit hours for One Health topics	**DVM	Credit hours for One Health topics	***MPH courses credit hours ()	Credit hours for One Health topics
Immunology and microbiology (2)	2	Bacteriology (4)	2	Principles of environmental health (3)	3
Public health assessment tools (2)	1	Parasitology (4)	2	One Health: public health applications (3)	3
		Pathology (4)	1	Health policy and management (3)	1
		Virology (3)	2	Social and behavioral aspects of public health (3)	1
		Veterinary public health (2)	2	Practice and leadership of public health (3)	1
		Avian, fish, and exotic diseases (3)	1	Community medicine seminar series (3)	1
		Pathology II (4)	1		
		Small animal medicine (3)	1		
		Livestock medicine (2)	1		
	3 (0.03%)		10.2 (1.5%)		10 (24%)

**MD program has a total of 86 credits plus 2 years clinical training.*
***DVM program has a total of 127 credits plus 1 year clinical training.*
****MPH program has a total of 42 credits.*

knowledge about the interconnection that exists between animal, human and environmental health embodied by OH on human health (20–22).

STUDY SETTING

The location of the study is a private medical University, based in the Caribbean. The DVM program is accredited by the American Veterinary Medical Association (AVMA) and the Royal College of Veterinary Surgeons (RCVS); the MPH program by the U.S. Council on Education for Public Health (CEPH) and the MD program by the US National Committee of Foreign Medical Education and Accreditation (NCFMEA). Dual degree DVM MPH and MD MPH students share classes with each other and also with the stand-alone MPH students. **Table 1** depicts the portion within each curriculum (credit hours) that includes coverage of topics relevant to One Health such as antimicrobial resistance, zoonoses, foodborne diseases of animal origin, and environmental health.

The institution has made very deliberate interventions to make OH a core tenet of its MPH degree. One major change implemented within our MPH degree program was the creation of the mandatory course: "One Health: Public Health Applications." Thus, not only freestanding MPH students, but all dual degree students are required to take this course. Further, OH issues are being highlighted in many of our other courses, specifically the course on the "Principles of Environmental Health." Hence, the MPH program can be used as a model for others to follow. Given the focus on OH in the MPH curriculum, it is anticipated that medical (MD) and veterinary (DVM) students pursuing a concurrent MPH may be more aware of the relevance of the interconnection between the sectors embodied by OH, compared to MD and DVM students in standalone programs. Insights from this study will be useful to inform the inclusion of OH content in future curricula.

METHODS

We declare that we obtained Institutional Research Board (IRB) approval for this study. The participants were emailed a copy of the Participant information form 1 week prior to receiving the link to the survey. The survey requiring them to define and explain the relevance of OH, was embedded within the Qualtrics platform. The consent form was also embedded within the Qualtrics platform. Participants indicated their agreement to participate electronically by selecting yes or no, after having read the consent form. Participation was voluntary, and all possible identifiers have been removed to maintain confidentiality of participants in published material.

Data Collection

The results presented in this paper form part of a larger Mixed Methods Research (MMR) study that was undertaken for a doctoral thesis (23). We invited 864 students in the third year of the MD, DVM program and all dual degree MD MPH and DVM MPH students to participate in a survey. Students invited to participate in the study had to have completed infectious disease courses relevant to understanding OH. The survey was distributed using the Qualtrics platform during October-November 2018. Email reminders were sent to student responders to encourage their participation in the survey. Four hundred and twenty-eight students completed the questionnaire. We then invited faculty and administrators across the schools to participate in focus group interviews to provide their perspectives on the student survey responses. This enabled verification of the

TABLE 2 | Demographics of student participants.

Variable		MD	DVM	MD MPH	DVM MPH	Total
Gender (428)	Male	99	11	50	<5	164
	Female	133	65	43	15	256
	I prefer not to say	<5	<5	<5	<5	7
	Other	<5	<5	<5	<5	<5
Ethnicity (428)	Black/African American	40	<5	12	<5	56
	Asian	63	<5	33	<5	101
	Hispanic or Latino	20	7	6	<5	34
	White	78	58	25	16	177
	Native American	<5	<5	<5	<5	<5
	Other	36	5	18	<5	59
Age Range (428)	18–24	59	21	15	9	104
	25–34	168	56	72	9	305
	>35	10	<5	7	<5	19
Nationality (428)	US/American	176	69	62	17	324
	Canadian	13	6	11	<5	30
	Asian	7	<5	5	<5	13
	Caribbean	23	<5	10	<5	33
	African	10	<5	3	<5	13
	Other	<5	<5	<5	<5	8
	British	<5	<5	<5	<5	<5
	European	<5	<5	<5	<5	<5
Total by Program		237	78	94	19	428

themes identified, and minimized any possible researcher bias in the lead researcher's interpretation of the responses, given her role as a veterinarian. The faculty also presented their perceptions of the needs, opportunities and challenges for developing OH in the medical and veterinary curricula, and discussed the development of a vision statement for the University to achieve its execution of its claim to support the One Health philosophy.

The student survey consisted of the Readiness for Interprofessional Learning Scale (RIPLS) (24) and asked students if they are familiar with the term OH. If so, two open-ended follow-up questions were asked with the following instructions: (1) How do you define the concept of OH? and (2) What do you consider the relevance of the OH concept might be to your practice as a global health professional? Additional questions required students to provide demographic data pertaining to their age, gender, ethnicity, nationality, program of enrolment, prior public health experience, and familiarity with OH. **Table 2** depicts the student demographics.

The analysis of the student responses from the RIPLS questionnaire now form part of a recently published paper by the authors (19). Student responses on the definition of OH and its relevance to practice are the focus of the present article.

Data Analysis

The researchers used NVivo version 12 software as a tool for organizing the data from the student responses into case files at case nodes according to the programs represented in this research (DVM, MD, MD MPH, DVM MPH). Braun and Clarke's (25) six step process was used to conduct thematic analysis on the participant responses pertaining to OH. Themes and subthemes were identified emerging from the student responses through inductive reasoning.

To interpret the findings of this study, we used the structuralist lens of Role theory (26) which proposes that professional role expectations are influenced by the individual's institutional context and the culture of their professional program. As mentioned above, DVM, MD, and dual degree MPH students have different expectations of their professional role, which is expected to influence their views about the meaning and relevance of One Health, and by extension collaborative practice.

RESULTS

The results presented in this paper follow on from findings presented by Roopnarine and Boeren (19) elsewhere. Based on an analysis of the students' scores from the RIPLS (24), it became clear that students undertaking an MPH are more ready for learning cooperatively with other medical students and by extension collaborative practice. These results highlighted the need to further invest in the development of Communities of Practices (27) to encourage MD and DVM students and faculty to engage in shared projects and learning events. Underpinned by the philosophy of OH, this might then lead to an established culture of collaborative learning and the development of an interprofessional identity among all students, not just MPH students. Together with the focus on "readiness for interprofessional learning," this study also investigated students' familiarity and understanding of the OH concept. It is this part of the research that is being presented in this paper.

Of the 428 students that participate in the survey, 322 students (75 percent) indicated their familiarity with the term "One Health." Among those 322 students, 265 students wrote down a definition of One Health (121 MD students; 67 DVM students; 61 MD MPH students, and 16 DVM MPH students) and 273 students (122 MD students; 72 DVM students; 62 MD MPH students, and 17 DVM MPH students) described the relevance of OH to their future practice.

Outcomes of the analysis of definitions and the understanding of the relevance of OH as provided by students will be presented below. Within each theme we first describe how students defined the concept of OH generally, and then focus on how they define the relevance of OH as it pertains to their future professional practice. Three themes will be discussed and will expand upon the students' perceptions on the linkages between human and animal health and the role of environmental issues in a globalized world. As will be evident from the sections below, students from different programmes vary in the importance they attribute to human, animal, and environmental aspects in discussing One Health.

Theme 1: Interprofessional Collaboration and Zoonoses Prevention

The participant responses to the questions requiring them to define the OH concept and its perceived relevance to their future practice that support this theme, are shown here in **Table 3**.

TABLE 3 | Interprofessional Collaboration and zoonoses prevention.

Questions	Participant responses
Definition of One Health	*DVM student: Medical professionals working together to improve the health and well-being of humans and animals.* *DVM student: Being able to allow veterinary medicine and human medicine to interact together with a common goal and protect everyone against zoonotic diseases.* *MD student: The concept of interdisciplinary cooperation and degrees of integration between the fields of Medicine and Veterinary Medicine driven by the significant impact of each field on the other, and the need to enhance effectiveness in the prevention and treatment aspects of patient care on individual and societal levels.* *MD student: Cooperation in research & practice between MDs and DVMs* *MD MPH student: "Physicians, Veterinarians and public health professionals working together to educate patients and practice preventive medicine to improve the health of all species."* *MD MPH student: One health is an approach to implementing policies and legislation in which multiple sectors work together to achieve a better health outcome. These may include preventing spread of infectious diseases and combating antibiotic resistance.*
Relevance of One Health	*DVM student: MDs and DVMs being able to work together when there is an outbreak to figure out the best way to control it.* *DVM student: Veterinarians are an important resource for pet owners, farmers, …to receive information regarding zoonoses…veterinarians may also be a useful resource for medical practitioners in quickly identifying such infectious diseases with which the practitioner may be less familiar.* *MD student: As a medical professional focusing on health and human illness, I must focus on zoonoses. If I pay attention to how an animal's life may be affecting my patients, I may be more likely to recognize a zoonotic disease if present.* *MD MPH student: Maintaining global relationships with Vets, engineers, physicians, government, and corporate officials to address important global health issues.*

Across the different programs, students predominantly defined the concept of OH as representing the collaborative partnership between veterinarians and medical doctors. However, there were distinct disciplinary differences, with MD students far less likely to mention partnership with veterinarians. DVM students, on the other hand, were very clear about the human-animal link embedded in the OH concept and the need for collaboration with medical doctors.

For the MD students, human health emerged as the key theme associated with the concept of OH, although, the occasional MD student saw the collaboration between human and veterinary medicine as key to the concept. DVM students tended to define this collaborative partnership between medical doctors and veterinarians with a stronger focus on protecting the public from zoonotic diseases.

There is a clear link between zoonosis and OH for DVM students, which highlights for them the collaboration necessary across the human-animal boundary. This cross-boundary definition was also apparent with the dual degree students. However, the dual degree students defined the concept with a more embracing type of collaboration, involving a wider group of health professionals than the MD and DVM students. The dual degree students often saw the relevance of the concept as embracing collaboration to optimize the health of all species by collaborating at the "*multisectoral*" level using "*transdisciplinary*" approaches to solving issues and tackling these at the "*local, regional and global levels.*" They also frequently included the notions of prevention and education within their definitions of OH.

Unlike the dual degree students, few MD and DVM students defined OH in association with health policy formation, although, some viewed OH as including"*epidemiological tracking of disease*" along with measuring the "*social/economic impact of disease in which policy is key.*"

On reflecting on why there were differences in how students perceived the type of interprofessional collaboration that defined OH, we identified a number of factors. Medical students expect to work with nurses and other allied human health professionals in their clinical rotations and then to see interprofessional practice as collaborations between these groups of practitioners. MPH students undertake courses on health policy formation that expose them to the role of government officials in driving policy changes. Veterinarians are focused on zoonoses prevention as crucial to their role in protecting public health and thus this may explain their focus on collaboration with medical doctors for this purpose.

In discussing the relevance of OH to practice, students differentiated on the emphasis placed on zoonoses in the collaboration between MDs and DVMs. Although, MDs were clearly aware of the relevance of OH for preventing zoonoses occurrence in their patients, DVM and DVM MPH students felt greater responsibility to prevent zoonoses in animals as key to their role in educating and working with the medical doctor to protect the public's health. For the veterinarians, the relevance of OH to their practice was tied into the vets' role in educating the medical doctor on the impact of zoonoses on human health. While DVM students frequently mentioned specific zoonoses of concern such as "*Ebola," and "rabies*" it was noticeable that for the MDs, examples of specific zoonoses of global health importance were omitted in their responses about the relevance of OH.

In contrast to the MD and DVM students, dual degree students perceived the relevance of OH to practice through its inclusion of government officials and public health workers in these collaborative efforts for driving health policy changes. This relevance of OH, outside of direct patient care (animal or human) found in dual degree students perhaps reflects why some chose to enroll on the dual degree. Their views of possible future practitioners is not confined to direct patient care as was commonly found with single MD or DVM students.

Theme 2: Incorporation of Environmental Health and the Expanded Area of Climate

The participant responses to the questions requiring them to define the OH concept and its perceived relevance to their future practice that support this theme are shown here in **Table 4**.

The second theme identified, in terms of defining OH and discussing its relevance, reflects the inclusion of environmental health and potential threats. In defining OH, again there were

TABLE 4 | Incorporation of environmental health and the expanded area of climate.

Questions	Participant responses
Definition of One Health	*MD MPH student: One health means that we are focusing on all aspects of our environment—humans, animals, all aspects of the living environment and human action (factories, etc.,)—in our definition of what affects our health* *MD student: Concept that the health of human beings is connected to animals and the environment.* *MD student: One Health describes the importance of global health…how air, water, sanitation, environment, and climate change impact global health.* *DVM MPH student: "The interweaving of animal, human and environmental health and its overall impact on the welfare and well-being of the global community.* *DVM MPH student: One Health is based on the principle that humans, animals, and the environment share a web of interconnections and the health status of any one of these affects the others. One Health is achieved when the highest level of health in humans, animals and the environment is reached.*
Relevance of One Health	MD MPH student … *Furthermore, human activities have caused significant damage to the environment and natural ecosystems, which in turn could have devastating consequences to human, animal, and plant health ….public health challenges we face include pollution of the atmosphere …., deforestation, …… urban expansion and poor land management, ……, loss of biodiversity and ……, and climate change/global warming.* *DVM MPH student: Not only will my job be to protect and treat animals, it will also be my duty to protect humans by controlling zoonoses transmission. This will also involve protecting and promoting environmental health by working to reduce harmful emissions and combat climate change to further reduce the prevalence of vectors that spread zoonotic diseases.* *MD student: We need to be aware of the factors that impact patient care outside of their control: environment, economic, social, political.* *MD student: To have a better understanding of how the environment that my patients are in, and zoonotic factors, can affect their health.*

TABLE 5 | Human health and the expanded areas of antimicrobial resistance, human-animal bond and food systems.

Questions	Participant responses
Definition of One Health	*MD student: the integration of medical aspects, and various professions that focus on the well-being and health of the public."* *MD student: One Health is an organization that wants to provide the best healthcare to people across the globe* *MD student: One Health means to combine all forms of healthcare and health education to provide quality care to all individuals, It not only focuses on screening, but on patient education. This allows for development of sustainable care.* *MD student: The interpersonal relationship between physicians, patients, and researchers to improve medicine.* *MD student: One Health to me is treating the whole person, not just the illness. It means asking not only about physical signs of illness, but also about what may be affecting their mental and emotional state.*
Relevance of One Health	*DVM: It is extremely important to understand the ways in which drug residues can affect consumers. As a food animal vet it will be my job to ensure the safety of food that many people consume on a daily basis."* *DVM student: Healthy animals have also been linked to decreasing depression, and other mental illnesses …..* *DVM student: Zoonoses, antibiotic resistance, pandemics-its important to work with MDs to prevent them.* *MD MPH student: Encompassing various aspects of population health from prevention to social interactions so a holistic approach is achieved.*

distinct disciplinary differences noted. While some MD students recognized the role of the environment in the definition of OH, the environment was clearly omitted by most DVM students. However, the dual degree students were all clear on the role of the environment within the concept of OH. Some MD students defined the role of the environment within the concept as synergistic with human and animal health. While others saw the role of environmental health only as it was relevant to human health.

With regards to how students perceived the relevance of OH to their future practice, it was clear that for the dual degree students, the role of environmental factors was key. Specifically, they saw OH as relevant for managing the impact of "*biodiversity loss*," "*urbanization*," "*climate change and global warming*," "*air and water pollution*" and the occurrence of "*vector borne diseases*" on human and animal health.

When discussing the relevance to their future practice, the disciplinary differences continue as might be expected. The dual degree students clearly see a role for themselves in mitigating against the effects of environmental hazards on human and animal health, therefore, the concept of OH will have relevance to them in that role. Whilst a number of MD students included environmental factors in the definition of OH, they did not necessarily see that as being relevant to their future practice. In other words, although, they recognized the impact of the environment on human health, their role was not to manage those environmental factors, therefore, that aspect of OH was not seen as relevant to their practice. This links back to their lack of insight into a possible role in influencing health policy and other public health measures. However, where the environment was recognized as part of OH, they did it as relevant in the care of their patients. The notable absence of environmental health in DVM students' definition of OH was understandably reflected in their views on its relevance, marking a stark difference to their DVM peers undertaking an MPH degree.

Theme 3: Human Health and the Expanded Areas of Antimicrobial Resistance, Human-Animal Bond and Food Systems

The participant responses to the questions requiring them to define the OH concept and its perceived relevance to their future practice that support this theme are shown here in **Table 5**.

Most MD students interpreted OH as solely defining the improvement of access to healthcare for PEOPLE, regardless of age, ethnicity and gender. What was specifically absent in the responses from MD students was an awareness of the role of animal health or to a lesser degree, environmental health. Their definitions of OH were predominantly indicating an approach to health for all humans, with very little understanding of the

TABLE 6 | Vision for the Institution.

Health will be perceived as the embodiment of a shared experience involving the preservation of animal, human, and environmental health for optimizing the health of all species and the environment they live in. Thus, it is the vision of this institution that medical and veterinary education will support and advance global health in its educational, research, and social activities within the framework and realization of the One Health concept. Shared interprofessional learning opportunities across the disciplines will promote the development of graduates that will transform healthcare through a collaborative approach to practice.

interconnection between animal, human, and environmental health. Their views included the need to provide optimal programs for healthcare, to considering the mental as well as physical health of their patients, in addition to other social and economic determinants of health.

The expanded issues referred to in this theme, antimicrobial resistance, food safety and the human-animal bond, were only apparent in the responses of the DVM students responding to the question about the perceived relevance of OH to practice. DVM students associated OH with their key professional role to protect the public health from issues such as antimicrobial resistance and foodborne diseases of animal origin. DVM students mentioned their role to consider the safety of *"human workers. . . .and other consumers"* and their role in foodborne disease *"outbreaks."* A number of DVM students highlighted the importance of the animal-human bond as beneficial for optimizing human mental health. DVMs were clearly aware of the link between animal and human health promotion and OH was viewed as relevant to that aspect of their practice.

Generally, across the themes identified above, responses indicate that students across all programs perceived the relevance of OH to their future practice. The way they view this responsibility differs across the programmes, but they all see it as relevant to their contribution to health issues in a global world. In general, the dual degree students have a more inclusive definition of OH and their envisaged role is more likely to encompass human, animal, and environmental health. In addition, they view their future role more broadly than treating their human or animal patients, envisaging a role in developing and influencing public health policy, which the single degree students did not express in this study. As part of this MMR study, the faculty discussions led to the creation of a vision statement shown in **Table 6**, for the University to provide an expectation to future student recruits across the disciplines about the type of medical education they will be receiving.

DISCUSSION

As discussed at the start of this paper, it is important for future medical practitioners to be familiar with the concept of OH in order to deal with urgent medical issues. However, not all medical curricula pay significant attention to OH, resulting in insufficient understanding of this concept among the student population. These gaps in the curriculum seem to relate to the impacts of global warming on human and animal health; food security concerns; the impact of socio-cultural and environmental factors on the occurrence of zoonoses; the role of the human-animal bond on human mental health; the role of the MD and DVM in response to pandemics such as SARS-CoV-2, health policy development and the implications of antimicrobial resistance for public health.

Work by Chapman and various of her colleagues, as discussed above, indicated a need for health professional students to be prepared for collaborative practice in the future and to better understand the interactions between human, animal, and environmental health spheres (7, 12). Amihasun et al. (14) paid specific attention to the need for a more holistic approach to diagnoses to be developed among MD students as this would help them to better consider the impact of animal and environmental factors on their patients' health. Decaro et al.'s (15) focus on veterinarians needing to step up to be at the forefront of policy changes during pandemics such as COVID-19 highlighted another need for introducing students to OH. However, our data show that not all students in our study demonstrated high levels of awareness of these issues, hinting at significant gaps in the university's curricula.

Through the inclusion of the dual degree MPH students in this study, evidence arose that the MPH curriculum is closing some of these knowledge gaps for MD and DVM students who are enrolled in the dual degree programme. As introduced above, the introduction of OH is more prominent in the MPH curriculum than in the standalone MD and DVM programmes and these dual students are thus more aware of the need to work along the human, animal, and environmental spheres of health issues.

Exploring the relationship between human and animal health, Rabinowitz and Conti (28) discussed that medical doctors are expected to advise clients on proper hygiene when handling pets and referring clients to a veterinarian to choose an appropriate pet, recognizing the mental health benefits provided by human-animal bonding. Most of the MD respondents however did not mention these aspects of the concept of OH. The DVM and DVM MPH in contrast to the MD students were aware of the risks of two critical issues to human health: food security issues and antimicrobial resistance.

Specifically in relation to the interface between animal and human health on the one hand and environmental health at the other hand, the awareness of health factors affected by globalization are especially important in the current day context of a pandemic (29). Addressing global zoonotic diseases like COVID-19 that impact human and animal health, requires collaborative OH approaches by social, public health, environmental, medical, veterinary, and social care professionals (30–32). Hence, MD and DVM students must be aware of the social, economic, and epidemiological disease determinants that lead to zoonotic diseases that are relevant to international health practice (33). It was clear from our data that MD MPH and DVM MPH students demonstrated a more sophisticated understanding of OH and its relevance for their own professional practice compared to MD and DVM students in the standalone programmes. MD and DVM students seemed unaware of the relevance of key global issues such as climate chance to OH and by extension to their future roles in clinical practice.

While DVM students frequently mentioned specific zoonoses of concern it was noticeable that MDs students omitted these reflections on the link between zoonoses and global health as part of their responses to questions about OH. None of the MDs mentioned specific zoonoses of global relevance which is consistent with Rabinowitz and Conti's (28) observation that medical curricula tend to place little emphasis on zoonoses and even less any mentioning of OH content. MD students also seemed unaware of the impact of global warming on the rise of vector borne diseases, natural disasters, the occurrence of heatstroke and respiratory diseases and allergies on their patients. This is a worrying result as Chapman and Dunham (34), discuss that zoonoses and antimicrobial resistance "exemplify" (p. 332) OH. Chapman and Dunham (34) discuss that increasingly, environmental health, food security, antimicrobial resistance should be incorporated within medical curricula as essential OH competencies. They argue such competencies are necessary to address global threats by stakeholders across the nexus of animal, human and environmental health. The occurrence of natural disasters resulting from climatic change (35) coupled with transboundary diseases in animals subsequent to global trade, has compromised agricultural production globally (36). The latter has led to a reduction in food availability and food security affecting 820 million persons globally, reflecting the urgent need to build partnerships to achieve these goals (36).

DVM students often omitted to consider the role of the environment as relevant to their future practice in animal health, even though climate change and global warming are known to have implications for heat stroke in animals. There was no consideration of the influence of social and behavioral or cultural factors on zoonoses occurrence by the DVM respondents. Given the current climate of global health, it was surprising that DVM students did not mention the behavioral factors such as bushmeat consumption on Ebola occurrence or the spread of highly pathogenic H5N1 avian influenza viruses causes by close contact between humans and domestic poultry in rural global environments. Importantly, there was little mention of the impact of global warming on the spread of vector borne diseases, or the role that human destruction of wildlife habitats has on placing humans at greater risk of zoonoses exposure through increased contact with wildlife reservoirs. It seems in this sample, that DVM students did not consider these issues will be relevant to their future practice as veterinarians. These findings may be partly explained by the fact that while DVM students are exposed to discussions on the impacts of climate change and socio-cultural factors on zoonoses occurrence in their veterinary public health course, environmental impacts on animal health are not discussed in the DVM curriculum.

Having identified gaps in the current MD and DVM understanding of OH and its relevance, we examine how those gaps can be addressed in the curricula. We agree with the observation by Rabinowitz and Conti (28) that with OH the lack of coverage of environmental health in the MD and DVM curricula is an issue, and that this will have a knock- on effect on how future practitioners will be able to deal with global disease threats. Food security, adequate water and air quality should be discussed as key to preventing the occurrence of infectious diseases (28). In the MD curriculum, there is also the need to directly address the connection between animal and human health, and raise awareness of the interprofessional collaboration across that boundary (6). While dual degree students identified all of these areas as key to the relevance of OH and to their public health responsibilities as future practitioners, these aspects also need to be integrated in the MD and DVM curricula.

Focussing on the DVM curriculum in particular, it is recommended that students should receive exposure to more structured OH content that brings in environmental health content that enables them to be aware of their role in mitigating the impacts of wildlife habitat destruction that has implications for both loss of biodiversity as well as zoonoses emergence (37). DVM students should have curricula content exposure that promotes their awareness of their role in mitigating the impacts of global warming and other environmental hazards (9, 37). Disease concepts relevant to ecosystem health and environmental perspectives on aspects of herd management could be considered within DVM curricula. As Stephen (9) discusses, mitigating the impacts of outbreaks such as foot and mouth disease would require students to have the skills required to engage multiple stakeholders in formulating policies to deal with mass animal destruction and carcass disposal, and for addressing the impacts of these outbreaks on communities. Kaufman et al. (38) discuss how Tufts University in the US, has integrated core principles of ecosystem health across both its 4-year core curriculum as well as through elective opportunities for students with a special interest in the field of conservation medicine.

As introduced above, role theory (26) help understanding our findings too. MD and DVM students construct their imagined futures as practitioners in a specific way. This often includes working in silos from each other. As Rabinowitz and Conti (28) discussed, MDs are aware of their role in treating zoonoses in their patients but do not tend to do this in collaboration with veterinarians. As Steele et al. (8) argued, students need to be made more aware of their joint responsibilities in tackling diseases, underpinned by a stronger need for communication between diverse health professionals, more engagement in teamwork, and a better understanding of each other's specific roles. Raising this awareness should ideally start at university. As discussed by Steele et al. (8), Gibbs and Gibbs (16), and Rabinowitz and Conti (28), professional roles and expectations should be clearly articulated to future OH veterinarians and medical doctors as part of the curriculum. Through the inclusion of the dual degree students, this study provides a novel insight into how the content of an MPH curriculum closes gaps on specific environmental health knowledge that is evident within the MD and DVM programmes. For the DVM MPH and MD MPH students, the role of the environment in the OH concept was recognized as necessary, suggesting that there is an expectation among these students to link environmental health content to their practice. This view is supported by others (11) who discuss the benefits of public health education, proposing that public health education enables students to consider the multifactorial causes of disease, thus promoting efforts to minimize climate change.

CONCLUSION

The study was unique in that it provided novel insight through the inclusion of dual degree MPH students alongside MD and DVM students for illustrating the advantage of familiarizing MD and DVM students with the principles of OH for practice. The study also used the lens of role theory for showing the relevance of OH and by extension students' perceptions on collaborative practice within their future professional roles. A limitation of this study is that we relied on student responses from open-ended questions on an online survey which did not provide the opportunity to seek further clarification from anonymous student respondents. However, the anonymity was designed to reassure respondents that they could express their views freely without fear of being "wrong." Research findings are limited to one institution only, so contextual issues may strongly influence findings. However, the findings seem to be largely in line with studies elsewhere, which is reassuring.

The comparative perspectives provided in this study, specifically by including dual degree students exposed to OH through the MPH have significant implications for recommending curriculum changes toward incorporating content on OH as fundamental to producing globally ready medical doctors and veterinarians (39). The MPH program and its related content can provide guidance for how OH may be successfully integrated and delivered within these core programs.

In this study, the authors did not seek to change the role definition for the future medical doctor and veterinarian nor to increase the curriculum workload. Rather the findings of this study demonstrate that having an awareness of the multiplicity of causal factors can lead to a better understanding of how complex health issues can be addressed. For too long, efforts to manage infectious diseases such as Highly Pathogenic Avian Influenza (HPAI), Ebola and now COVID-19 by international health agencies has failed. The zoonotic and environmental origins of these deadly disease threats adds significant weight to the argument for the need to prepare future health professionals to act to mount an effectual public health response to these threats, necessitating the inclusion of OH in the curricula of the MD and DVM programmes (40).

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.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by St George's University Institutional Research Board (IRB) and the University of Liverpool Virtual Programs Research Ethics Committee (VPREC). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RR was the principal investigator and provided the conceptual framework for the study and conducted the research. J-AR and EB were the doctoral supervisors for the principal investigator.

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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.

The reviewer BK declared a past collaboration with one of the authors RR.

frontiers in Public Health

BRIEF RESEARCH REPORT
published: 25 August 2021
doi: 10.3389/fpubh.2021.736005

Variations in COVID-19 Spread and Control Measures in the Palestinian Territories

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Palestinians are facing the epidemic while they are the only occupied country globally, with around 2 million inhabitants under siege in the Gaza Strip (GS) for the last 14 years and have no control over the health of the Palestinians in East-Jerusalem (EJ). Such catastrophic situations created a variety in the spread of the COVID-19 pandemic in different territories. This study aimed to explore variation in COVID-19 spread, risk factors, and intervention activities in the three Palestinian territories: West Bank (WB), EJ, and GS to learn from the current gaps to overcome this pandemic and be prepared for future emergencies. Epidemiological data regarding COVID-19 were obtained from online websites, Palestinian national reports, WHO reports, and scientific publications. Morbidity and mortality indicators in Palestine are higher than the global level with rate variation in the three territories. COVID-19 incidence and mortality rates are higher in EJ and lowest in GS, while case fatalities are around 1% all over the country. Social gathering and lack of readiness of the fragmented health systems (there are two systems; Palestinian serves the WB and GS and Israeli serves the EJ) are risk factors in the three Palestinian territories. The most prominent risk in GS is overcrowding, while the movement of the workers inside Israel and travel are more prevalent in the WB and EJ. The WHO and international organizations play an active role in responding to a community spread, mainly national coordination, risk communication and community engagement, laboratory support, surveillance and procurement, and supply management. Recommendations include restructuring the national committees, reviewing and standardization of the national protocols, expanding infections prevention training, supporting and developing the capacity of laboratories, and setting the role of NGOs besides community engagement and participation.

Keywords: COVID-19, control measures, Gaza Strip, East-Jerusalem, West Bank—Palestine

OPEN ACCESS

Edited by:
Ulrich Laaser, Bielefeld University, Germany

Reviewed by:
Silvia Gabriela Scintee, Management and Professional Development, Romania
Madhumita Dobe, All India Institute of Hygiene and Public Health, India

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Specialty section:
This article was submitted to Environmental health and Exposome, a section of the journal Frontiers in Public Health

Received: *04 July 2021*
Accepted: *27 July 2021*
Published: *25 August 2021*

Citation:
Abed Y, Shaheen A and Abedrabbo A (2021) Variations in COVID-19 Spread and Control Measures in the Palestinian Territories. Front. Public Health 9:736005. doi: 10.3389/fpubh.2021.736005

INTRODUCTION

Palestinian territories are located on the eastern coast of the Mediterranean Sea. The remaining area from Palestine is divided into two geographically distinct regional units, the West Bank (WB) and the Gaza Strip (GS), while East-Jerusalem (EJ) and areas classified as "C" are under the control of Israel. According to the Palestinian Central Bureau of Statistics, the total population in 2017 was about five million, among them two million throughout the last 14 years locked in the Gaza Strip (GS). With its 365 km^2, the GS is one of the most densely populated areas in the world (5,324 people per square kilometer) to be 10-fold higher than the WB population density (1). In one of

the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) camps, population density reaches over 80,000 per square kilometer (2).

Palestinians are facing the pandemic while they are the only occupied country in the world and have no control for the health of the Palestinians in EJ. Such catastrophic situations created a variety in the spread of the COVID-19 pandemic in the different territories. In this study, we tried to demonstrate the fight of the Palestinians to ensure control of the pandemic under challenging circumstances.

In December 2019, a respiratory coronavirus emerged from a large metropolitan area in China's Hubei province, Wuhan. Most cases present with fever, dry cough, and tiredness, although clinical presentation ranges from asymptomatic to atypical severe pneumonia (3). By March 11, 2020, the WHO declared the COVID-19 pandemic (4). Preventive measures are the only solution to save lives and provide the countries with more time to prepare for the arrival of the virus (5). However, within a short time, the disease spread to include most of the countries in the world. In Palestine, the first case was reported in Bethlehem city in the WB on March 6, 2020. The effort focused on the complete isolation of the town and the closure of markets, schools, universities, mosques, churches, and a ban of major social gatherings. In Gaza, the first two cases appeared 3 weeks later than in the WB (March 26, 2020), which allowed time to prepare the same regulations.

This study aimed to explore the variation in COVID-19 spread, risk factors, and intervention activities in the three Palestinian territories: West Bank, East-Jerusalem, and Gaza Strip to learn from current gaps, to overcome the current pandemic, and face future emergencies.

STUDY OBJECTIVES

1. To explore differences in morbidity and mortality indicators in the Palestinian territories,
2. To reveal differences in risk factors for the COVID-19 spread in the three territories,
3. To compare the response to the pandemic in the Palestinian territories,
4. To formulate recommendations to policymakers to overcome the pandemic.

METHODOLOGY

Epidemiological data regarding COVID-19 were obtained from online websites, mainly from the Palestine COVID-19 website (https://www.corona.ps/details) and the Worldometer for coronavirus (https://www.worldometers.info/coronavirus/), and from the Palestinian national reports, WHO reports, and scientific publications. The research team reviewed these data, and the following rates were calculated: the cumulative incidence and COVID-19-specific mortality and case–fatality rates (CFRs). In the end, we compared the reported data in the three study territories.

We abstracted the morbidity rate by calculation of the cumulative incidence rate per 1,000 inhabitants by dividing the cumulative number of the reported cases divided by the total population of the country multiplied by 1,000. Two indicators were calculated for mortality, first was the COVID-19-specific mortality rate calculated by the total number of COVID-19 deaths in the country divided by the total population of the country and multiplied by 100,000. The second mortality indicator is the COVID-19 case–fatality percentage and calculated by dividing all cases of COVID-19 deaths by the reported number of reported cases and multiplied by 100. Covid mortality reporting was based on COVID-19-positive testing and the death certificates reporting following the COVID-19 guidelines of the WHO for death certification and coding (ref). Rates were calculated based on the Palestinian Central Bureau of Statistics (PCBS) estimate of the Palestinian population (WBG) (5,227,193) in the WB (3,120,448), GS (2,106,745), and EJ ID holders (428,304) (6).

For calculation of the risk factors, crowding was calculated by the population density as measured by the number of the population per square kilometer while travel limitation for Gaza population based on the WHO and The UN Office for the Coordination of Humanitarian Affairs (OCHA) reports. Readiness of health services was based on the MOH and international reports. Responsiveness to the COVID-19 pandemic is based on comparing MOH reports with the WHO components to respond to the community spread of COVID-19 (7, 8).

RESULTS

The study results are presented in three major components, and each part shows the variation among the three Palestinian communities in:

1. COVID-19 morbidity and mortality.
2. Risk factors for COVID-19.
3. Responsiveness to the COVID-19 pandemic.

VARIATION IN COVID-19 MORBIDITY AND MORTALITY

Table 1 shows the cumulative incidence rate per 1,000 inhabitants, COVID-19-specific mortality rate per 100,000 inhabitants, and case fatality as a proportion of deaths from all the COVID-19-confirmed cases in the Palestinian territories and selected countries.

The reported COVID-19 morbidity and mortality is acceptable compared with those of the other countries but higher than the global average. The cumulative incidence rate for COVID-19 is 41 cases per 1,000 inhabitants, 2.7-folds more elevated than the global cumulative incidence of 15 and similar to Jordan with 42 but less than Lebanon with 58. Countries such as the United States, Israel, and the United Kingdom reported higher incidences, possibly due to massive community screening where tests in these countries exceeded the number of the population. In contrast, Palestinians reported a low rate

TABLE 1 | COVID-19 in selected countries, mid-March 2021.

Country	Cases/1,000	Deaths/100,000	Case fatality %	Tests/1,000
World	15	34		
United States	98	162	1.65	1,114
Israel	87	64	0.73	1,357
United Kingdom	62	183	2.95	1,416
Turkey	33	34	1.03	403
Egypt	2	11	5.50	10
Jordan	42	48	1.14	478
Lebanon	58	75	1.30	467
Palestine	**41**	**43**	**1.06**	**248**
East-Jerusalem	63	55	0.87	
West Bank	47	53	1.12	
Gaza Strip	27	26	0.98	191

Rates were calculated based on the PCBS estimate of the Palestinian population (WBG) (5,227,193) in the West Bank (3,120,448), Gaza Strip (2,106,745), and East-Jerusalem ID holders (428,304) (6). Data were abstracted from https://www.corona.ps/details, https://www.worldometers.info/world-population/state-of-palestine-population (https://www.worldometers.info/coronavirus/).

TABLE 2 | Summary of the variation of risk factors for COVID-19 for the three territories.

Risk	Gaza	West Bank	E. Jerusalem
1.Overcrowdness Population density	+++++ 5,324 persons per km^2	++ *509 persons per km^2	+++
2.Travel and movement	+	++	+++
3.Worker risk	+	++	+++
4.Social gathering	+++	+++	++
5.Health readiness shortage of	+++	++	+
A. Diagnostic facilities	+	++	+++
Intensive care beds	+	++	+++
Ventilators devices per 100,000	4	10	
O_2 Generators	++	++	++
Medications	+	++	+++

**https://www.pcbs.gov.ps/Portals/_Rainbow/Documents/Land-use-table%201E-2019.html.*

of tests completed per 1,000 inhabitants: 238 tests per 1,000). Two mortality indicators are considered: COVID-19-specific mortality rate per 100,000 and case fatality as a percentage. The first mortality indicator shows that the COVID-19-specific mortality rate in Palestine with 43 is higher than the global rate of 34 and similar to the Jordanian rate but less than those of Lebanon, Israel, and the United States. Case fatality reflects the severity of the disease and the response and capability of the health services to manage the reported cases. In Palestine the CFR is around one, a little higher than that of Israel but lower than those of Lebanon and Jordan. The lowest case fatality was reported in GS as shown in **Table 1**.

By mid-March 2021, the reported cumulative incidence was 41 per thousand inhabitants with variation between the territories, the highest in EJ with 63 per thousand and the lowest was in the GS with 27 per thousand while WB reported 47 cases per thousand inhabitants. This variation in the reported cases between the three territories was due to the low traffic movement in the GS because of continuous closure of the borders, specifically Rafah. The GS saved 7 months with zero community transmission due to the restrictive measures of 21 days isolation of all travelers coming to Gaza at the beginning of the pandemic. The situation was different in EJ and WB: transmission of new strains of the virus between Israel and the WB was enhanced by the 180,000 Palestinians working inside the Greenline and Palestinians holding EJ and Israeli IDs. In addition, there is no security control; hence it was difficult to control the pandemic. More than 800 cases were reported in the WB from English and South African strains.

The differences in the cumulative incidence affected the specific mortality rate per 100,000 inhabitants to be highest in EJ (55) followed by the WB (53) and the lowest rate reported in the GS (26), the total specific mortality rate for Palestine to be 43 per 100,000 inhabitants. Despite the variation of COVID-19-specific mortality rate in the Palestinian territories, CFR at Eastern Mediterranean Region reached 2.37% on January 30, 2021. The highest was in Yemen (29%) (9). In Palestine, the case fatality was around 1%, with the lowest in EJ (0.87).

VARIATION IN RISK FACTORS

Studies showed common risk factors for spreading the disease in different countries, including overcrowding, travel between countries, social gathering, availability of health services, and the response of the health authority to the event. **Table 2** shows a summary of the variation of risk factors for COVID-19 for the three territories.

Overcrowding

Overcrowding is a known risk factor giving the chance for spread among the population. In the GS, the population density is among the highest globally, with 5,324 inhabitants per square kilometer. Thus, the population density in the GS is 10 times higher than that in the WB, keeping the population in GS at an increased risk of the rapid spread of the infection. Yet, the opposite happened as described above.

Travel and Movement

There are marked differences between the Palestinian territories in control of the borders, either at entry or exit to the GS, closed during the last 14 years. This situation created geographically and security-wise a status different from the WB and resulted in limited movement between the GS and the external world. The crossing areas of the GS are controlled at only two points, the Beit

Hanon (Eretz) crossing for those coming through Israel and the Rafah crossing for those coming through Egypt. This negatively affected the socioeconomic status of the population and imposed significant obstacles in patient referrals outside the

GS. It also created substantial barriers in drugs, medical supply, and equipment to the GS. For the WB, the crossings with Israel faced problems due to the diversity of crossing points and the loss of security control by the Palestinian side. In contrast, EJ and areas "C" are entirely controlled by Israel. As a result, many Palestinian workers from the WB pass through these crossings and constitute a high risk of virus transmission from Israel to the Palestinian territories. During the early stages of the pandemic, 75% of the positive cases recorded in the Palestinian territories were workers inside Israel and their contacts. The same applies to the border with Jordan, which remained open for a while.

Social Gathering

Social gathering is typical in all the Palestinian territories without variation; wedding parties and funerals were the most common factors in spreading the disease in the Palestinian territories. The same applied to educational institutions, market gathering, and general transport with limited precautions. In addition, social groups included religious places such as mosques and churches, especially on Fridays for Muslims and Sundays for Christians.

Readiness of Health Services

Political insecurity and socioeconomic instability have affected the health of the population and the ability of Palestinians to develop a modern health system, particularly intensive care rooms, respirators, and lack of access to serve residents in the neighborhoods of EJ and the occupied areas "C" in the WB. The respirator rate in Palestine is 10 devices per 100,000 citizens and 4 in the GS. Compared to other countries, these rates are 30 in Germany and 50 in Israel, while Israelis seek to raise them to 150 devices per 100,000 inhabitants (10). The impact of the political split has been severe and harms the population of the GS. In addition, there is a chronic shortage of essential medicines and health supplies for more than one-third of what is needed, especially in emergency rooms, operation theaters, intensive care units, orthopedic services, nephrology centers, and neonatal care units. The Palestinian people have faced many restrictions that have affected their ambition to create a functional Palestinian health system during the last 14 years. In East-Jerusalem isolation and restriction is a major factor as residents are unable to access Israeli hospitals (11).

RESPONDING TO COMMUNITY SPREAD OF COVID-19 VARIATION

In this part of the results, we followed the WHO components to respond to the community spread of COVID-19 (7, 8). WHO experts set technical guidance of 10 items to help government authorities, health workers, and key stakeholders to guide response to community spread of the disease. We compared the three Palestinian communities for each of these items.

National Coordination

There are central committees and regional committees to support coordination, planning, and monitoring. Examples of major committees are the National Epidemiology Committee and the Vaccine Purchase Committee. These committees were formed with EJ, WB, and GS and chaired by the Minister of Health. At the same time, there are committees in both WB and Gaza to support the authorities in planning and surveillance of events. These committees are advisory committees to respond to the situation based on the variation of case occurrence and the health facilities available in each Palestinian territory. However, they often lack efficient coordination. In most instances, WHO, UNICEF, and the National Institute of Public Health are also present in regional committees and play a significant role in standardizing plans and monitoring.

Risk Communication and Community Engagement

The WHO supports this area through Health Cluster meetings: international and local organizations monitor risk communication and community engagement. All the results are shared with the Palestinian side (12). One example is this site where all materials are categorized under one of these groups: general advice, hand washing, hygiene, quarantine and isolation, COVID-19 vaccine, education, face masks, family care, gender-based violence, nutrition and exercise, physical distance, safe shopping, stigma and discrimination, and the workplace. Each category of the above contains videos, health messages, social media cards, radio spots, and brochures. Most of them are published on Facebook, Instagram, and Twitter (see example in the references further). Modern technology makes all material available to all Palestinian sites (13, 14).

Public Health Measures

There are variations in the Palestinian territories in public health measures due to variation in time of community infection, available facilities, and controlling authorities. **Table 3** shows variations and similarities in the different localities.

The first case was reported in Bethlehem city in the WB on March 6, 2020, the government efforts focused on the complete isolation of the town and the closure of markets, schools, universities, mosques, churches, and a ban of major social gatherings. As for the GS, since March 15, 2020, all travelers, coming in through one of the two crossing points, were transferred to a compulsory quarantine at one of the MOH designated facilities (15). The quarantine period exceeded the 14 days recommended by the WHO by an extra week to avoid possible incubation periods longer than 2 weeks. In Gaza, the first two cases appeared 3 weeks later than in the WB (March 26, 2020), which allowed time to prepare the same regulations. Nevertheless, the community spread of the virus was first reported in GS by August 16, 2020. As a result, immediate and vigorous lockdown for the entrance points was implemented immediately, followed by gradual canceling of the compulsory quarantine and replaced by a medical check-up and PCR testing. Likewise, the Palestinian authorities declared emergency status for WB by the day of discovering the first case. They also called for the closure of educational and religious facilities and ordered restrictions on gatherings and movement between cities. The first lockdown lasted from March to May 26, 2020, but was soon followed by further restriction measures. Subsequent lockdowns resulted in a reduction of registered cases. Palestinians in EJ are

TABLE 3 | Summary of the interventions for COVID-19 for the three territories.

Intervention	Gaza	West Bank	E. Jerusalem
Date of new cases discovery	Among Quarantines: March 26, 2020 Community cases: August 16, 2020	March 6, 2020	March 23, 2020
Quarantine Measures	All people enter Gaza 21 days starting March 15, 2020	Starting March 6 to May 26	
Quarantine period	21 days	14 days	14 days
Closure and Governorate separation	Once August 26, 2020	First time March 6, 2020	March 19 to May 4; July 6 to October 18; and again, on December 24 to January 9*
Night closures + Saturday and Sunday	Nov 15, 2020 to February 4, 2021	During the summer and again in November and December	On September 6, the Israeli government approved night-time curfew
Chances of vaccination**	Expected to have 40% of all vaccines arriving Palestine	120,000 workers inside Israel had the chance to get the Vaccine	Have better chances for vaccination within the Israeli system

*http://www.wclac.org/files/library/21/03/m8bwzl5xfxczrncl5ygkyi.pdf (16).
**Recent immunization data are available on: www.emro.who.int/pse/palestine-infocus/situation-reports.html.

subject to Israeli public health regulations besides lockdown with closures and restrictions for three cycles (16).

Case Management and Health Services

The blockade imposed on the GS deprived the developmental activities and prevented the entry of equipment, medicines, and diagnostic materials, deteriorating the diagnostic and treatment facilities. The technical committee developed protocols to ensure proper diagnosis and management of COVID-19 (17). Those protocols were based on the WHO publications and the frequent modifications (18). Unfortunately, those committees worked separately in WB and GS despite the personal communications between the scientists on both sides and participation in zoom meetings in training sessions with international conferences. Currently, there are two versions of protocols, one for the WB and one for the GS. Training sessions were completed through in-service training for the health staff. The training covered infection prevention, diagnostics, oxygen therapy, antimicrobials, mechanical ventilation, sedation, best practices to prevent complications, liberation from mechanical ventilation, quality in critical care, pandemic preparedness, and ethical considerations. The training was organized by MOH/Human Resource Education or through funded activities by international organizations, national and international NGOs, and electronic communication with experts from outside the country. The recent zoom meetings gave equal chances for experts from GS, EJ, and WB to meet and share the learning experience with international experts. These programs reached about approximately 2,000 health care workers.

Infection Prevention and Control

Prevention of infection was planned at three levels: first, support of health education activities focusing on the importance of wearing face masks, hands wash, and surface disinfection. Second, closing overcrowded places such as schools, universities, mosques, sports clubs, wedding halls, funeral homes, and major markets. Third, isolation of communities with confirmed cases, either by curfew or restriction of movements between communities. In the early stages of the pandemic, all three levels were implemented in the WB, while in the GS activities were limited to the first two levels, sufficient to delay in the GS community transmission for 7 months. Finally, all health staff were trained for rational use of personal protective equipment and infection prevention. Training covered especially the following topics: IPC, infection transmission, hand and respiratory hygiene, injection safety, decontamination, environmental cleaning, and waste management. Despite these efforts, Gaza reported 437 COVID-19 cases among the health workforces during 1 week based on the local MOH report dated April 17, 2021.

Surveillance and Risk and Severity Assessments

Palestine adopted the WHO case definition for COVID-19 and issued a daily report for GS, WB, EJ, and Palestinians in diaspora (https://corona.ps/). The report contained some new cases in each governorate, the cumulative number of cases, active cases, cured cases, and total deaths. In addition, curves demonstrated daily changes in the related indicators. Palestine also participated in the WHO serosurvey for COVID-19 in WB and GS. Recently, in addition, a surveillance system of vaccination activities was established, which allows collecting data on vaccine types and complications.

National Laboratory Systems

Facing the current pandemic requires the preparation of laboratory facilities to respond to a vast number of sampling testing for diagnostic, follow up, and surveillance purposes, besides laboratory facilities for blood, urine, and stool samples of patients. The major problem faced by the MOH is the availability of PCR testing where machines and swabs were not available. WHO suggested the support of the National Public Health Laboratory in Ramallah/WB to carry out PCR testing for both the WB and the GS. However, WHO supported GS Lab with a PCR machine and swabs as it turned out not to be easy to send the GS samples to WB. Under the control of MOH, permission was given to NGOs to conduct the COVID-19 PCR testing. Protocols were developed on how to collect, transport, and examine the samples. The epidemiology and laboratory teams were trained accordingly. With the spread of different COVID-19 strains to the WB and GS, special kits posed additional costs.

Logistics, Procurement, and Supply Management

The Health Cluster Committee (chaired by the WHO and the MOH) calls for international sources and regulates the distribution in WB and EJ. In addition, direct purchase in Ramallah and Gaza is made to face urgent requests. At the same time, direct donations for GS or WB are registered in the main stores and distributed based on need. A good example is also the establishment of the National Committee for Vaccine Purchase.

Maintenance of Essential Services

In the early days of the pandemic (March 6, 2020), several Primary Health Care (PHC) centers were closed in both GS and WB to give support to hospitals in preparation and epidemiological investigations. WB health centers suffered more due to staff barriers to reach their working places. However, based on the WHO recommendations, essential health services should continue during emergencies, particularly immunization programs, antenatal care services, and care of chronic patients (19). During the first 3 months, UNRWA provided most of the PHC activities and established a public hotline to serve people with home treatment and health consultations, ready to reach all those registered for non- communicable disease services. Also, social assistance at home was secured to avoid overcrowding in the centers. Furthermore, UNRWA offered vaccination programs for children. Later, starting from August the first wave started to decline in the WB and started to increase in Gaza and the centers were gradually reopened in most of the territories.

Health Cluster Committee continues to monitor the status of service provision in the Palestinian localities. For example, they stated that: "In Gaza, 27 (84%) fully functioning hospitals, 5 (16%) partially functioning hospitals, 135 (91%) functioning primary health care clinics, 5 (3%) partially functioning primary health care clinics, 9 (6%) not functional." Also, in the same report, with regard to NGOs providing services through mobile teams in closed areas and areas facing a shortage of health staff in the WB: "8 mobile medical teams/clinics currently provide primary health care services." All partners continued efforts to ensure continued access to essential services, such as primary healthcare, sexual and reproductive health, surgical care, nutrition, as well as mental health and psychosocial support (19).

Research and Development

Palestinian researchers participated in some local and international research studies. Members from Palestinian universities in WB, GS, and EJ published papers about the prevalence of risk factors for COVID-19, satisfaction with the services, etc.

Knowledge, attitude, and practice studies among the population about the pandemic and perceptions of health care workers regarding local infection prevention and control procedures. PCBS, MASS, MASARAT, PINGO, and others published relevant reports. The American Arab University in Jenin completed genotyping studies. Juzoor University completed a study on the impact of the COVID-19 outbreak and lockdown on family dynamics and violence (20). The Palestinian Public Health Institute participated in the WHO sero-surveillance study. Studies are ongoing on the impact of COVID-19 on health services. Palestinian members in the scientific committee follow recent studies for COVID-19, searching for evidence of decision making and development of protocols and guidelines. It is worth to note that most of the studies are social and simple epidemiological studies due to the absence of research laboratory infrastructures in Palestine.

DISCUSSION

Globally, most countries experienced facing COVID-19 pandemic with the difference in the severity of spread, complications, risk factors, and variation in response mechanisms. Palestinians faced the pandemic under difficult political situation presented by a political division between the GS and the WB beside uncontrolled for parts in the WB and EJ. Our findings showed differences between the Palestinian territories where, the COVID-19 incidence and mortality rates were higher in EJ and lowest in GS, while case fatality was around 1% of all cases all over the country with minor variation between the three localities. However, we expected a higher incidence in the GS because of the 10-fold higher population density, which did not happen either due to political blockade on Gaza preventing the movement of travelers or due to under-reporting of cases. The reported COVID-19-specific mortality rate of Palestine was 43 per 100,000 was higher than the global rate of 34 per 100,000 and similar to the Jordanian rate but less than those of Lebanon, Israel, and the United States. The high reported rates in the United States of 162 and England with 183 can be explained by a high proportion of the aged population with higher risk for COVID-19 complications. Higher case fatalities in the United States and England reflect the severity of cases among the aged population and could be attributed to different strains. Anyhow, mortality comparison between countries is no easy task because of the differences in population structure and inaccuracy of diagnosis of the cause of the death and real implementation of the WHO guidelines in practice within countries (21, 22).

This study showed variation in risk factors between the three territories. The most prominent risk in GS was overcrowding, while the movement of the workers inside Israel and travel is more prevalent in WB and EJ. The social gathering was one of the major risk factors for reporting a cluster of cases among the Palestinian population. In the GS, where there is a low traffic movement, despite having the highest population density, it was the lowest cumulative incidence and the lowest COVID-19-specific mortality, among the three Palestinian territories. Besides, Gaza followed quarantine measures—all travelers coming to Gaza in the first 7 months of the pandemic were placed in a 21 days isolation quarantine. During the 7 months, the GS with the support of the WHO and donor community got a chance to prepare the health care system by improving the laboratory facilities, increasing the number of intensive care units, oxygen generators, personal protective devices, and training of the staff.

Variation in response mechanisms to the COVID-19 pandemic is associated with the unique political situation that

created a complex environment with major obstacles blocking short-term solutions for the current health problems and preparedness for expected epidemics. Overcrowding,' movement of workers, and change of the population social gatherings are not easy risk factors to overcome. At the same time, political changes by removing border restrictions and ending the occupation although that it is a necessity but in reality, no active steps are seen soon. Based on that the authors set their recommendations that could be applied to minimize the current health hazards and to enable the health care system to face the current pandemic and future undesirable events based on the current COVID-19 experience.

During the current COVID-19 pandemic, WHO played an active role in preparedness and response to face the pandemic in Palestine. Coordination through Health Cluster group made fare distribution of the international support by donor communities that enabled Palestinians to support the emergencies in the three territories. The study showed the importance of the formulation of the National Committees and the regional subcommittees and their major role to coordinate different activities to ensure proper surveillance system and fair distribution of the available resources and follow the international scientific regulations to standardize the control measures all over the Palestinian land. Following the WHO guidelines to respond to the COVID-19 pandemic helped the Palestinians to develop their capacities to face the pandemic. National committees have been formed which meet and exchange information and scientific documents regularly. The committees recommended public health measurements implemented based on the situation in each territory. The technical committee succeeded to develop protocols for case management based on the WHO guidelines, which require further modifications to ensure the use of one National protocol based on the COVID-19 experience. Palestinians have to benefit from the health cluster experience to support coordination with the international and donor communities and based on the experience of the current national committees, restructuring of the different scientific committees will minimize the variations between the territories and improve communication and future interventions.

The pandemic revealed that there is a major gap in the health care system toward infection prevention as a high number of infected health workforces remain as a public health problem despite training courses and the provision of personal protective devices.

By Palestinian Public Health law (23), control of the epidemics is the responsibility of the Government and all services are free from fees. One major achievement during the pandemic is the maintenance of essential health services such as basic immunization program, Ante Natal Care, and Non-Communicable Diseases management. That was not possible to achieve without full cooperation with the other health care providers. Mainly UNRWA, NGOs, and the private sector. UNRWA supported the provision of PHC services and later prepared their centers to be ready for population vaccination. NGOs reached isolated communities, provided PHC services and elective surgeries besides their role in supporting risk communication and community engagement activities. This experience guided the health policymakers to reset the role of the different health care providers during a normal situation and during emergency time.

The time of the pandemic was not easy for the Palestinians and all the world countries, but we have to learn from all these lessons how to improve the health care system and to be ready for any future pandemics.

RECOMMENDATIONS

1. Restructure of the national committees to be one central and two regional sub-committees, one for EJ and WB and one for GS, and to generalize this structure for different national committees to ensure standardization of the Palestinian health care system.
2. Review and standardize all national protocols, guidelines, and curricula for training.
3. Expansion of infections prevention training to all health care facilities and health-related higher education faculties.
4. Support and development of laboratory capacity in both WB and GS to ensure the capability to face emergencies.
5. Setting the role of NGOs during a normal situation and during emergency time.
6. Support of the research infrastructure to help Palestinian researchers to meet the community needs and contribute to an international network.
7. Community involvement and participation to support the official authority in the field to implement their plans and activities. However, clearly defined tasks are needed.

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

YA gathered the data and analyzed and drafted the text. AS provided East Jerusalem Data and revised the text. AA matched the data with the MOH reports and revised the text. 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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 24 September 2021
doi: 10.3389/fpubh.2021.720006

Quality of Life and Factors Affecting It: A Study Among People Living Near a Solid Waste Management Facility

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Background: The amount of waste generated has been increasing over the years. Meanwhile, the capacity of solid waste management facilities (SWMFs) for waste disposal does not meet the needs, resulting in adverse consequences on the natural environment and health of residents living near these plants, which can significantly degrade their quality of life (QoL). This study aims to evaluate the QoL of residents living near an SWMF and the potential impacts it has on the residents.

Methods: A cross-sectional descriptive study was conducted involving 801 subjects, aged 18 and above, who live near the SWMF of Hue City, Vietnam. The QoL of the subjects was quantitatively assessed using the WHO QoL assessment scale (WHOQOL-BREF). The general, health, and environmental factors influencing QoL were identified using bivariate and multivariate logistic regression analyses.

Results: About 22.6% of the subjects had a good QoL. In particular, the proportions for good psychological health (6.9%) and environment (13.6%) were low, indicating an influence of the SWMF. Significant factors that degraded the QoL of residents were less education defined by not graduating from high school (odds ratio, OR = 2.78; 95% CI = 1.09–7.06), poor health status (OR = 2.50; 95% CI: 1.56–4.01), dissatisfaction with water quality (OR = 2.41; 95% CI: 1.10–5.25), and unacceptance of the SWMF presence (OR = 1.70; 95% CI: 1.11–2.60). Moreover, subjects living within 2 km of the plant had dermatological diseases and digestive disorders more frequently than those who lived away from the plant. They also reported more complaints regarding water, air, and soil quality, which were likely due to the operation of the SWMF.

Conclusions: Burying and disposing of solid waste at the SWMF might lead to the degradation of the surrounding water and soil environments, and its collection and transportation are considered to cause odor and dust. The efforts of responsible authorities to strictly supervise and inspect these activities at the SWMF are essential, not only to protect the surrounding environment but also to improve the QoL of those who live nearby these plants.

Keywords: quality of life, WHOQOL-BREF, environmental health, developing country, solid waste management facility

OPEN ACCESS

Edited by:
Ulrich Laaser, Bielefeld University, Germany

Reviewed by:
M. A. Karim, Kennesaw State University, United States
Gulnihal Ozbay, Delaware State University, United States

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Specialty section:
This article was submitted to Environmental health and Exposome, a section of the journal Frontiers in Public Health

Received: *03 June 2021*
Accepted: *25 August 2021*
Published: *24 September 2021*

Citation:
Phan LT, Nguyen GT, Nguyen QAD, Nguyen HS, Nguyen TT and Watanabe T (2021) Quality of Life and Factors Affecting It: A Study Among People Living Near a Solid Waste Management Facility. Front. Public Health 9:720006. doi: 10.3389/fpubh.2021.720006

INTRODUCTION

The rapid breakthroughs of industry and technology have improved the quality of life (QoL) of people worldwide. However, as a result of these developments, waste management and treatment have become challenging for human life in the twenty-first century. It is estimated that the rate of waste accumulation is even faster than the rate of urbanization (1). For example, a study reported that humans have produced 8.3 billion tons of plastic waste since the beginning of the industry in the 1950's, but only a negligible 9% of them was recycled, 12% was burned, and the rest was discarded and buried worldwide (2). Such waste originates directly from daily activities and sometimes causes serious issues for the natural environment, e.g., air pollution, contaminated grounds, and results in poor human health, such as diarrhea, respiratory illnesses, or cancer (3–5). Furthermore, as demonstrated in research, the environment surrounding a solid waste management facility (SWMF) and the groundwater resource systems were also seriously damaged because of the long-term operation of such plants (6). Moreover, along with the unsustainable use of natural resources and inappropriate environmental management, the QoL of residents living near these SWMFs is also negatively affected due to their operation (6–9). Even in developed countries, despite the promulgation of policies and strategies on waste recycling and disposal, the effectiveness of these policies is very limited. For example, only 25.8% of the waste in the USA was recycled in 2017, and countries in the European Union were in a similar situation, with only 30% of the waste recycled every year (10–12).

The QoL of a population can be affected by environmental factors. For example, the QoL of people, particularly in terms of physical and psychological domains, was negatively impacted by air pollutants, toxins, noise, and dirtiness in a study in Colombia (13). In Vietnam, a typical developing country in Asia, the amount of domestic waste in urban areas nationwide was 38,000 tons per day in 2015, 85% of which was collected and treated (14). However, in the same year, the amount of domestic waste in rural areas was 32,000 tons per day, and only approximately 55% was collected (14). Domestic waste is mainly treated by burial (70%), leading to rising indignation among people living near unsanitary landfills (15). Furthermore, its detrimental effect on water and soil environments has not been investigated well. Moreover, burning without closed processing technology, which is likely to degrade the air environment, is another popular waste treatment (up to 28%) in Vietnam (16). These treatments of domestic waste have likely contributed to the ranking of the country of 77/132 countries in an overall environmental assessment by the Environmental Performance Index in 2015 (17). Specifically, air pollution (for which Vietnam is in 123rd place) has had the most detrimental effect (17). According to a study conducted in Ho Chi Minh City, Vietnam, in 2016, a 10 $\mu g/m^3$ increment in air pollutants increased the risk of respiratory diseases from 0.7 to 8.0% and that of cardiovascular diseases from 0.5 to 4.0% (18).

Thua Thien Hue (T. T. Hue) Province is a center of economy and tourism in central Vietnam with a local population of over 1.1 million and more than 4 million tourists visiting in 2018 (19). The pressure for waste treatment in this province has invariably been high, and an SWMF started operating in 1999. The treatment capacity is approximately 480 tons per day and solves the problem of household waste disposal. In the treatment plant, the waste is sprayed with antiseptic chemicals, followed by a process of waste categorization, composting, and combustion. The inert waste is dumped into a nearby landfill. However, the increasing amount of waste has overloaded the capacity of the SWMF, which has likely caused environmental pollution with negative impacts on the QoL of people living in this area. Even in this situation, they seem to be unaware of its long-term impacts on their QoL due to a lack of knowledge of these issues or a belief that the authority is responsible for providing a better waste-recycling system (20).

While previous studies mainly assessed the impact of SWMFs on health problems experienced by nearby residents, other aspects such as mental health, social skills, and the environment have been scarcely discussed (21–25). Considering these aspects, this study aims to evaluate the QoL of residents as a comprehensive indicator of the impact of the SWMF for people living nearby. This study uses the WHO QoL assessment scale (WHOQOL-BREF), which has been used to measure the QoL, both for the general population and those suffering from different diseases (26–28). This study also aims to determine factors influencing the QoL of the residents. To the best of our knowledge, this is the first study to investigate the QoL of people living near an SWMF in the Southeast Asian region.

MATERIALS AND METHODS

Study Design

This cross-sectional descriptive study was conducted from May to August 2019 in a town near Hue City, the capital of T. T. Hue Province in Vietnam. The required sample size was calculated as 768, based on the previous research (29). A multistage stratified sampling method was used to select participants. First, the town involved in this study, which comprises 12 wards, was separated into two regions based on the distance from the SWMF (one within 2 km and the other distance away from the SWMF). Then, two wards from each region were randomly selected, and 10 hamlets were randomly isolated from the four selected wards, and the number of subjects from each hamlet was determined to correspond to its population (**Appendix 1**). Only those subjects in compliance with the following criteria were included in the study ($n = 801$): (1) aged 18 or above, (2) had lived continuously in the target area for at least 6 months before the study, and (3) willing to be involved in the study. Those who were in a state of cognitive impairment, difficult to contact, suffering from a mental illness, hearing or speech impaired, and those who could not control their actions and thoughts mentally were excluded. This exclusion may have contributed to the overestimation of

Abbreviations: SWMF, Solid waste management facility; QoL, Quality of life; WHO, World Health Organization; WHOQOL-BREF, World Health Organization Quality of Life; T.T. Hue, Thua Thien Hue Province; OR, Odds ratio; CI, Confidence intervals; SD, Standard deviation.

QoL by neglecting a certain number of people with low QoL, although its contribution cannot be considered.

Measures and Instruments

The WHO QoL assessment scale (WHOQOL-BREF) was used (30). The QoL was quantified based on four main domains, namely, physical health, mental health, environment, and social relationships. This scale is one of the most widely used tools in QoL research as it enables us to assess individual perceptions in the context of their culture, personal goals, standards, and concerns (30, 31), and it has been widely field-tested and validated (32, 33). The WHOQOL-BREF includes 26 items from four aforementioned main domains with a relatively high consistency (Cronbach's alpha = 0.826). These facets were scored on a Likert scale of 1–5 with 1 = very poor, 2 = poor, 3 = neither poor nor good, 4 = good, and 5 = very good; and 1 = very satisfied, 2 = dissatisfied, 3 = neither dissatisfied nor satisfied, 4 = satisfied, and 5 = very satisfied; 1 = not at all, 2 = a little, 3 = a moderate amount, 4 = very much, and 5 = extremely; or 1 = never, 2 = seldom, 3 = quite often, 4 = very often, and 5 = always (30). Then, we used a specific formula to compute scores for each domain based on this Likert scale (**Appendix 2**). The overall evaluation of QoL was determined by averaging the scores of the four domains. The QoL was assessed based on the scores obtained, following a previous study of the QoL of Indian women, where the following criteria were applied: those who obtained scores <33.3, 33.3–66.7, and >66.7% were judged to have poor, average, and good QoL, respectively (34). In this study, the assessment was simplified by comparing the score <66.7% with that >66.7% to understand whether the subjects have a good QoL or not.

To determine factors influencing the QoL, general characteristics of the research subjects, including gender, age, marital status, economic status, occupation, educational level, number of persons living together, and duration of their living in the target area, were obtained through direct interviews. The subjects were also asked orally about their general health status, past illnesses, treatment history, and satisfaction levels with air, water, and soil qualities, and noise in the living environment. The interviewers, who were 5th-year students at Hue University of Medicine and Pharmacy, were well-trained to minimize potential biases in the answers collected from the subjects. In the training, the students received detailed explanations about the objectives of the research, the structure of the questionnaires, and how to avoid obstacles during the interview, followed by trial interviews with eight local people under our supervision to strengthen their skills. During the trial interviews, we evaluated their level of proficiency and understanding of the questionnaire and their interview skills. Then, only those who thoroughly understood the questionnaire had strong interviewing capabilities, and appropriate attitudes to local people were assigned as interviewers.

As another environmental factor, the residential distance from the SWMF was considered by categorizing the subjects into two groups, with Group 1 ($n = 405$) comprising those living ≤2 km from the SWMF, and Group 2 ($n = 396$) those living >2 km from the SWMF.

TABLE 1 | Quality of life (QoL) of the research subjects on the WHOQOL-BREF scale ($n = 801$).

Aspects	Mean score ± SD	Subjects with good QoL (%)
Physical health	62.7 ± 12.4	41.8
Psychological health	58.0 ± 7.7	6.9
Social relationships	65.7 ± 13.6	45.2
Environment	56.8 ± 9.8	13.6
Overall evaluation	60.8 ± 7.7	22.6

Statistical Analysis

A chi-squared test was performed to analyze the associations between the score of the overall QoL evaluation and possible factors influencing it. A $P < 0.05$ was considered statistically significant. Subsequently, multivariate logistic regression (MLR) analysis was performed to evaluate the independent associations between the overall QoL and variables, which were significantly associated in the previous analysis. The odds ratio (OR) was used to assess the strength of the associations. SPSS 18.0 (developed by IBM Corporation, New York, USA) was used for all statistical analyses.

Research Ethics

This study was approved by the Hue University of Medicine and Pharmacy and the local authorities in the area where the study was conducted. Written informed consent was obtained from all participants after clearly introducing the survey process. The research subjects participated voluntarily and could refuse to participate or withdraw from the interview at any time. The data collected were used for scientific purposes only, and all information related to the subjects was encrypted and kept confidential.

RESULTS

QoL Assessment of the Research Subjects

Table 1 shows the QoL of the research subjects assessed on the WHOQOL-BREF scale. The overall assessment illustrates that only 22.6% of the residents had a good QoL. Physical health and social relationships contributed positively to the QoL, despite the fact that the mean scores were lower than the criterion (66.7). However, factors that led to lower QoL were clearly related to psychological health and environment, which may be attributed to the operation of the studied SWMF.

General Characteristics of the Research Subjects

Table 2 shows the general characteristics of the research subjects. The numbers of female and male subjects were approximately equal in this study. The average age of the subjects was 45.9 years, and one-fifth of them were over 60 years old at the time of this study. Furthermore, 88.6% of the subjects were married, and only 3.4% of them lived alone. Moreover, 4.1% lived in difficult economic circumstances, and more than 90% of the subjects had lived in the study area for more than 5 years.

TABLE 2 | General characteristics of the research subjects ($n = 801$) and the association with overall QoL based on the chi-squared test.

Factors		All		Overall QoL		*P*
		N	%	Not good ($n = 620$) (%)	Good ($n = 181$) (%)	
Gender	Women	427	53.3	344 (53.4)	83 (45.9)	0.052
	Men	372	46.4	274 (46.4)	98 (54.1)	
	Others	2	0.2	2 (0.2)	0 (0.0)	
Age	<60	622	77.7	475 (76.6)	147 (81.2)	0.191
	≥60	179	22.3	145 (23.4)	34 (18.8)	
Marital status	Not married	91	11.4	63 (10.2)	28 (15.5)	**0.048**
	Married	710	88.6	557 (89.8)	153 (84.5)	
Living alone	No	774	96.6	597 (96.3)	177 (97.8)	0.325
	Yes	27	3.4	23 (3.7)	4 (2.2)	
Educational background	Unschooled	70	8.7	64 (10.3)	6 (3.3)	**<0.001**
	Primary school	155	19.4	135 (21.8)	20 (11.0)	
	Secondary school	217	27.1	170 (27.4)	47 (26.0)	
	High school	195	24.3	146 (23.5)	49 (27.1)	
	University/postgraduate	164	20.5	105 (16.9)	59 (32.6)	
Financial status	Poor	33	4.1	30 (4.8)	3 (1.7)	0.058
	Average or above	768	95.9	590 (95.2)	178 (98.3)	
Time living in the study area	Under 1 year	6	0.7	3 (0.5)	3 (1.7)	0.169
	1–5 years	65	8.1	52 (8.4)	13 (7.2)	
	5–10 years	68	8.5	48 (7.7)	20 (11.0)	
	Above 10 years	662	82.6	517 (83.4)	145 (80.1)	
Self-report health status	Not satisfied	351	56.2	312 (50.3)	39 (21.5)	**<0.001**
	Satisfied	450	43.8	308 (49.7)	142 (78.2)	

Bold value means the P < 0.05.

Table 2 also shows the associations between marital status, educational background, self-reported health status, and the overall QoL ($P < 0.05$). Being married, having a higher educational degree, and being in good health were identified as significant factors that determined a better QoL.

Health Status of the Research Subjects

The aforementioned analysis revealed that 56.2% of the subjects were not satisfied with their current health status. **Table 3** shows the health problems reported by the subjects, which might be the possible reasons for their dissatisfaction. Health problems with a high incidence reported in the study area included musculoskeletal diseases (27.1%), chronic diseases (25.3%), and digestive disorders (25.0%). Meanwhile, the subjects who reported a "not good" QoL had higher incidences of musculoskeletal, respiratory, and chronic diseases ($P < 0.05$) than the other subjects; however, no significant difference was found in terms of digestive disorders.

Factors Influencing the QoL of the Research Subjects: Results of Multivariate Logistic Regression (MLR) Analysis

Table 4 shows the results of the MLR analysis conducted to identify factors that influence the overall QoL of the research subjects. This analysis involved only those factors that were significant in the chi-squared test (**Tables 2**, **3**; **Appendix 3**). The results showed that the overall QoL was influenced by the educational background, with those graduating from high school (OR = 2.78; 95% CI: 1.09–7.06; $P = 0.032$) and university (OR = 3.89; 95% CI: 1.52–9.99; $P = 0.005$) having a significantly better QoL. Independent of the educational background, satisfaction with general health status significantly increased the QoL (OR = 2.50; 95% CI: 1.56–4.01; $P < 0.001$).

Among the environmental factors, water quality had a significant relationship with QoL. The QoL of subjects who were unsatisfied with the water quality was significantly lower than that of subjects who expressed satisfaction (OR = 2.41; 95% CI: 1.10–5.25; $P = 0.027$). The existence of the SWMF was another relevant factor, as suggested by the fact that the subjects who reported being irritated by the plant had a lower QoL than those who reported "acceptance" for it (OR = 1.70, 95% CI: 1.11–2.60; $P = 0.015$).

DISCUSSION

Only a small proportion (22.6%) of the 801 participants was found to have a good QoL. The subjects in Group 1 reported

TABLE 3 | Health issues of the research subjects ($n = 801$) and the association with QoL based on the chi-squared test.

Diseases	All subjects ($n = 801$)		Overall QoL				*P* value
			Not good ($n = 620$)		Good ($n = 181$)		
	Suffered *n* (%)	Non-suffered *n* (%)	Suffered *n* (%)	Non-suffered *n* (%)	Suffered *n* (%)	Non-suffered *n* (%)	
Respiratory	145 (18.1)	656 (81.9)	127 (20.5)	493 (79.5)	18 (9.9)	163 (90.1)	**0.001**
Digestion	200 (25.0)	601 (75.0)	156 (25.2)	464 (74.8)	44 (24.3)	137 (75.7)	0.816
Dermatology	131 (16.4)	670 (83.6)	99 (16.0)	521 (84.0)	32 (17.7)	149 (82.3)	0.584
Chronic diseases	203 (25.3)	598 (74.7)	176 (28.4)	444 (71.6)	27 (14.9)	154 (85.1)	**<0.001**
Allergy	56 (7.0)	745 (93.0)	40 (6.5)	580 (93.5)	16 (8.8)	165 (91.2)	0.268
Blood	52 (6.5)	749 (93.5)	45 (7.3)	575 (92.7)	7 (3.9)	174 (96.1)	0.103
Musculoskeletal	217 (27.1)	584 (72.9)	187 (30.2)	433 (69.8)	30 (16.6)	151 (83.4)	**<0.001**

Bold value means the P < 0.05.

TABLE 4 | Factors affecting the quality of life of the subjects ($n = 801$) as the result of multivariate logistic regression analysis.

Factors		OR	95% CI	*p*-value
Educational background	Unschooled	1		
	Primary school	1.58	0.59–4.23	**0.366**
	Secondary school	2.44	0.96–6.19	**0.060**
	High school	2.78	1.09–7.06	**0.032**
	University/Post-graduate	3.89	1.52–9.99	**0.005**
Marital status	Not married	1		
	Married	1.05	0.62–1.77	0.871
Self-report health status	Not satisfied	1		
	Satisfied	2.50	1.56–4.01	**<0.001**
Respiratory diseases	Suffered	1		
	Non-suffered	1.51	0.86–2.64	0.152
Chronic diseases	Suffered	1		
	Non-suffered	0.97	0.57–1.65	0.912
Musculoskeletal diseases	Suffered	1		
	Non-suffered	1.22	0.76–1.97	0.414
Water quality	Not satisfied	1		
	Satisfied	2.41	1.10–5.25	**0.027**
Impact of the solid waste management facility	Not accepted	1		
	Accepted	1.70	1.11–2.60	**0.015**

Bold value means the P < 0.05.

poorer physical health than those in Group 2 ($P = 0.001$) (**Appendix 4**). A previous study in Korea also mentioned that a residence nearby a garbage-dumping site was negatively correlated with the physical domain of the QoL (35). Moreover, 57.8% of those in Group 1 thought that the operation of the plant had a negative impact on their lives (**Appendix 5**). This result is similar to a study in South Africa, in which 70 and 56% of residents living closer to the landfill site identified the deposition of municipal solid waste in landfills as a serious problem and had fears for their health in the future (36). In this study, although the QoL score for physical health was relatively high, significant differences in people suffering from dermatology diseases and digestive disorders were found between the two residential groups ($P < 0.05$) (**Appendix 6**). In contrast, the previous studies did not report any increases in illness (21) or demonstrate an increase in primarily respiratory diseases, eye irritation, and weakness of the body in populations living near wastewater treatment plants (23, 36). This could be attributed to different impacts of SWMFs and wastewater treatment plants, and local factors, such as the living environment, health status, climate, geography, genetics, and immune status of the population.

The QoL score of psychological health was relatively low (**Table 1**) regardless of the distance from the SWMF (**Appendix 4**). A higher QoL for this factor among senior residents was found in a previous study in Canada (24). It is

possible that the participants with higher education might be able to lead a more comfortable life even under the impact of the SWMF. In addition, a previous study conducted in Greece noticed that the frequency of being in a bad mood, being angry, and getting sick reported by the subjects was significantly higher among residents living close to a wastewater treatment plant than all others (21). Although the impact of a Greek wastewater treatment plant differs from that of the SWMF studied here, the result from the Greek study, in which the distance from the wastewater treatment plant might affect greatly the QoL in terms of psychological health, should be also considered when referring to the impact of the SWMF in this study. The psychological QoL was not significantly affected by the distance because the subjects in Group 2 were also psychologically stressed by the SWMF or were there other factors for the low QoL commonly found in both groups? Nevertheless, as aforementioned, the number of people with good psychological QoL in the study area was negligible. However, psychological QoL should not be overlooked due to related impacts on residents who live near the SWMF, in which air pollutants may cause neuropathies such as memory disturbances, sleep disorders, anger, fatigue, head tremors, blurred vision, and slurred speech, as well as affecting the dopamine system, glutamate system, and N-methyl-D-Aspartate (37).

Regarding the environment, the satisfaction of residents with the quality of their living area was the second lowest (13.6%) in both Groups 1 and 2 (**Table 1**). A previous study in Korea also indicated the environment as being significantly associated with a lower QoL of people living near a garbage-dumping site (35). Water quality is one of the environmental factors related to the QoL. Most of the research subjects used tap water for domestic purposes; however, 13.4% used water from wells and ponds for animal breeding and cultivation, making them vulnerable to the possible impacts of the SWMF on water quality. The most common visible changes in water quality were strange odors (61.8%) and colors (55.9%) for Group 1 (**Appendix 7**). Many subjects reported that the water quality had changed markedly after the construction of the SWMF, especially in ponds and groundwater from drilled wells. Although this study did not analyze the water quality of the study site, many studies also indicated detrimental effects of the SWMF on the water quality by showing the inevitable presence of bacteria and heavy metals in water samples near the SWMF (23, 38, 39). The presence of chemicals, heavy metals, and pathogens in water was one of the key factors that determined the risks for human health, which was indicated by the significant differences in the dermatological diseases and digestive disorders between Groups 1 and 2 (**Appendix 6**). These results were somewhat similar to the results of a study in Pakistan, which identified water-borne diseases, including diarrhea, cholera, typhoid, paratyphoid, hepatitis A, dermatitis, enteric fever, and many more as threats to the health of nearby residents, especially children and the elderly (40).

In addition, 64.9% of Group 1 residents reported experiencing polluted air around the SWMF, especially in the early morning, late evening, and after rain or weather changes, whereas only 39.4% in Group 2 experienced the same as Group 1 (**Appendix 8**). A study in Malaysia revealed that roughly 83.7% of respondents living within a 2 km radius of the landfill experienced a bad smell, which affected the tranquility and QoL (41). Furthermore, 90.9 and 4.6% of subjects in Groups 1 and 2, respectively, considered that odors and unpleasant air were caused by the SWMF, due to a great amount of unprocessed waste and the progress of combustion (**Appendix 9**). The study period from May to August was in the dry season characterized by a high temperature over 39°C and relatively low humidity (around 60% in the daytime), according to the provided data of weather from the Web Portal T. T. Hue (42, 43). With the dry and hot wind from the South or South-West in the study periods, air pollutants and odor are likely to have affected residents on the leeward side of the SWMF more significantly (44), although it cannot be examined with our data. This issue was significantly considered when a previous study in the greater Athens showed that air pollutant concentration within 1.5 km from the landfill was significantly above the WHO reference lifetime exposure health criteria (45).

Refuse dumps release bioaerosols in the atmosphere that are associated with pathogens known for causing fatal diseases such as cholera and diarrhea (46). Although there was no significant difference regarding respiratory diseases between the two residential groups in this research, this type of disease contributed significantly to the difference between having good and not good QoL (**Table 3**). This type of disease requires attention because of its latent dangers. Waste transportation, which can cause dust, was also identified as a negative factor affecting air quality. Although 12.6% of the subjects in Group 1 mentioned waste transportation, none of the subjects in Group 2 were reported as being affected by it (**Appendix 10**). This also requires attention because of the serious problems that waste transfer has caused, especially dust, which was a serious concern for people living near landfills (36, 47–49). The SWMF also caused negative effects on soil quality, in which 17.5% of subjects in Group 1 were negatively affected by the degraded soil quality, in contrast to Group 2 with 11.1% ($P < 0.05$) (**Appendix 8**). The contamination of soil may occur as leachate produced by water or liquid wastes moving into, through and out of the landfill; migration into adjacent areas can affect the site characteristics and environmental health extensively (50). Irrespective of the annoyed respondents in Group 1 regarding water, air, and soil environments, there was no correlation between the two groups in terms of noise (**Appendix 8**). This result is somewhat consistent with other studies, which found that residents do not consider noise from the landfill operation, including blowing refuse and truck noise, as serious problems (48, 51).

The MLR analysis involving all the subjects (**Table 4**) revealed that the significant factors influencing a low overall QoL score were poor educational background, dissatisfaction with health status and water quality, shorter distance from the plant, and unacceptance of the plant. These factors were also significant in Group 1 (**Appendix 11**), whereas they were not significant

in Group 2 (**Appendix 12**). In addition, in Group 1, higher-educated people had better QoL. The higher the level of education, the higher the perceived negative effects of the landfill operation, of the more education impacts their perception and independent solutions to the negative impact from the SWMF (52). The overall QoL was negatively affected by health status in both the groups, resulting in the lower QoL in terms of physical health in Group 1 (**Appendix 4**). Musculoskeletal diseases, which were significant factors regardless of the distance from the SWMF, were not associated with the SWMF when conducting the MLR analysis. Although there are no significant differences between musculoskeletal diseases along with respiratory and chronic diseases and QoL, an association between these diseases and the distance to the SWMF was found in previous studies (23, 36, 49). Therefore, substantial attention should be paid to the relationship between health issues and the distance to the SWMF. The dissatisfaction with water quality and unacceptance of the SWMF were not significant factors in Group 2, which indicated the extent of impacts of this plant. Meanwhile, these factors significantly affected the QoL of people in Group 1 (**Appendix 11**) in consistency with other studies (23, 48).

STRENGTHS AND LIMITATIONS

This study comprehensively evaluated the possible impacts of the SWMF on the QoL of people living in the study area, such as human health and environmental issues. A strong point of this research is that it provides precise data on the QoL of people by applying the WHOQOL-BREF, which has been widely used in previous studies. In addition, dividing the study area into two different regions based on the distance from the SWMF enabled us to highlight the possible impacts and relevant factors of this plant.

On the other hand, we did not incorporate other facilities, such as a paper factory, fish sauce company, and plastic factory, which might impact the QoL of local people. In addition to the responses from local people, because T. T. Hue Province was determined to have poor waste management and collection, our priority was given to the SWMF (53). Furthermore, we excluded people who do not meet the relatively strict requirements for being interviewed, which, although there were few, may have limited the study.

There are a few more limitations to this study. The results based on the data, which were collected in a short time, may not represent the seasonal variations. For example, weather-related factors such as temperature, humidity, and wind direction could be affected by seasons, underlying the necessity of follow-up longitudinal studies to examine the seasonal difference in the impact of SWMF. Moreover, this cross-sectional study cannot detect the causal relationship between the impact of SWMF and QoL. The absence of air, water, and soil quality measurements in this study also limits the discussion regarding the impact of the SWMF on environmental and human health. Monitoring the contaminants in these environments from the SWMF requires further investigation for a more reliable health risk assessment.

CONCLUSIONS

This study comprehensively assessed the impact of an SWMF in Hue City, Vietnam, on the QoL of its residents in terms of physical health, psychological health, social relationships, and the environment using the WHOQOL-BREF. The overall QoL was lower compared to the general criteria because of low scores in psychological health and environment. Among the possible influencing factors in these aspects, the residential distance from the SWMF was significant and shown to contribute to a lower QoL, along with poor education, dissatisfaction with health status and water quality, and unacceptance of the SWMF. Dermatological diseases and digestive disorders were reported more frequently, corresponding to the reported degradation of water quality, among those who live near the SWMF. Air pollution, such as odor and dust, and degraded soil quality also seem to make the plant unacceptable to residents.

Burying and disposing waste at the SWMF could degrade surrounding water and soil environments, and its collection and transportation are believed to cause odor and dust.

Based on the findings in this study, the efforts of responsible authorities to strictly supervise and inspect these activities at the SWMF can not only protect the surrounding environment but also improve the QoL of those who live near the plant. Their possible supervisions include updating the waste treatment technology, relocating the burial site containing unprocessed garbage and the combustion facility at least 5 km from residential areas (54), and prohibiting people from approaching the SWMF. In addition, other solutions to relieve the effects of the SWMF operation on the air quality of residential areas should be concerned, such as using panels to cover waste when it is transported to the SWMF to alleviate odors from waste trucks. Moreover, the authorities can also consider controlling dust emission from waste transportation by regularly spraying water on the soil (55).

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.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Hue University of Medicine and Pharmacy, Vietnam. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LP, GN, QN, HN, TN, and TW: conception and design. LP, QN, HN, and TN: collection and assembly of data. LP, GN, QN, HN,

TN, and TW: data analysis and interpretation. LP, GN, and TW: writing, review, and editing. All authors read and approved the final manuscript.

FUNDING

This work was supported by JSPS KAKENHI [Grant Number 19H01144], JSPS Core-to-Core Program, and SEI Group CSR Foundation.

ACKNOWLEDGMENTS

The authors would like to thank the local volunteers who helped with data collection.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.720006/full#supplementary-material

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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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 18 November 2021
doi: 10.3389/fpubh.2021.731272

Demographic Attributes of Knowledge, Attitude, Practices, and One Health Perspective Regarding Diarrhea in Pakistan

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Specialty section:
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

Received: 26 June 2021
Accepted: 04 October 2021
Published: 18 November 2021

Citation:
Abbasi A, Shahzad K, Shabbir RMK, Afzal MS, Zahid H, Zahid T, Ahmed H and Cao J (2021) Demographic Attributes of Knowledge, Attitude, Practices, and One Health Perspective Regarding Diarrhea in Pakistan. Front. Public Health 9:731272. doi: 10.3389/fpubh.2021.731272

Background: Loose bowels is a clinical sign of gastrointestinal transport channel proteins, channels, and physical and chemical boundaries being harmed, prompting issues of water and electrolyte transport in the intestinal system. It is still considered as a major reason for emergency visits to hospitals in low-middle income countries. Zinc is a suitable treatment along with ORS for diarrhea. KAP surveys are usually conducted to collect information about general or specific topics of a particular population. The objective of this study was to investigate the knowledge, attitude, practices (KAP), and one health perspective regarding diarrhea among the participants from urban and rural populations of Rawalpindi and Islamabad, Pakistan.

Methods: Data was collected by conducting a survey among residents of twin cities over a period of 6 months (from July 2020 to December 2020). The questionnaire compromised socio-demographic features and the degree of KAP with respect to diarrhea management and control. One way ANOVA tests were applied to observe the demographic relationship and various factors influencing knowledge, attitude, practices, and one health perspective about diarrhea.

Results: A total of 338 subjects participated in the study. Female subjects were in the majority with 63% while the rest were male. A majority of the participants were between 15–25 years of age and 79.6% participants were un-married. The leading ethnic group was Punjabi with 52.7%; the lowest ethnic group were of Sindhi ethnicity with 8.6%. Age has a significant association with respect to knowledge and attitude. Religion has a significant association with respect to knowledge, practices, and one health, while education/qualification has an association with knowledge. The rest of the variables found no association with each other.

Conclusion: It is concluded from the recent study that most residents of the twin cities of Pakistan knew about diarrhea and had a good attitude and practices toward it. Age, religion, and education have different roles regarding different diseases in the population of Pakistan. The current study has its limitations as well. Parts of the study were conducted in the capital of Pakistan which is more developed as compared to other areas of Pakistan. It would be better to explore the remote areas of Pakistan where basic amenities of life such as education, wealth, and unemployment are not available. It is important to create more awareness among community members. They should be aware how dangerous these viruses and bacteria can be. Other parts of Pakistan should also be explored for better understanding that will help in making a nationwide health policy.

Keywords: knowledge, attitude, practices, bacteria, viruses, pathogens and diarrhea

INTRODUCTION

Diarrhea is characterized as three or more loose or liquid stools passing through each day or more frequently than usual for the person. For the most part, loose bowels is a clinical sign of gastrointestinal transport channel proteins, channels, and physical and chemical boundaries being harmed, prompting issues of water and electrolyte transport in the intestinal system (1). With advancements in technology and the medical field, the mortality rate associated with diarrhea has reduced but it is still considered as a major reason for pediatric emergency visits in hospitals, particularly in low-income countries in Asia and Africa (2). The common cause for diarrhea is a variety of bacteria, viruses, and fungus (3). Due to poor hygiene, infection spreads by infected food or drink or from individual to individual. Diarrhea is a condition that is both preventable and treatable. Diarrhea fluid deficiency has fatal consequences and is the leading cause of malnutrition (4). It causes 1.3 million (M) deaths per year and is also a widespread health problem in the world (5).

The treatment of Diarrheal illness as per the World Health Organization (WHO) is Zinc supplementation along with ORS, which has emerged as a potent approach to treating Diarrhea (6). To meet the challenges of prevention of diarrhea, an effective public health program is needed which should include supplies of safe drinking water, zinc supplementation prevention/early correction of dehydration, ultraviolet purification filter plants, and advice on boiling of water at household level (7). Diarrhea can also be treated by Rehydration with intravenous fluids, Nutrient-rich foods including breast milk, and by giving a nutritious diet to children when they are well (8).

An expert consultation identified several barriers in reducing childhood diarrhea–related mortality (9). These included: the absence of national coordination within ministries and other stakeholders to deliver interventions, insufficient financial resources, inadequate training and support for health workers, poor systems for monitoring and assessing key programmatic indicators, and sporadic availability of key commodities. However, care–seeking behaviors by families, and their belief systems around diarrheal diseases, were not identified as possible barriers, although these are well-described in the literature (10).

WHO and UNICEF launched a comprehensive Diarrhea control plan in 2009 (11). Global Action Plan for Diarrhea has an ambitious goal of ending preventable childhood deaths by 2025, and to achieve that, it provides a set of priorities and interventions to scale-up progress at a country level (12). Integrated Global Action Plan for Diarrhea introduces a cohesive approach to ending preventable Diarrhea deaths. But to reach every child would require scaling-up and targeting of interventions known to prevent and control Diarrhea. Enabling this vision requires coordination and collaboration from child-health-related programs, parents, communities, community health workers (CHWs), civil society, and the private sector. Pakistan follows the WHO guidelines and policies in this regard (13).

A KAP survey is usually conducted to collect information on the knowledge, attitudes, and practices about general and/or specific topics of a particular population. KAP surveys can identify needs, problems, and barriers to help plan and implement interventions (14). It deepens the understanding of commonly known information, attitudes, and factors that influence behavior. KAP studies help in assessing and identifying communication processes and sources important for program implementation and effectiveness. It also helps to set program priorities and make program decisions (11).

There is a scarcity of data regarding the KAPs of diarrhea in the Pakistani community, so the present study was designed to assess demographic attributes of knowledge, attitude, and practices and to establish one health perspective toward diarrhea among residents of Rawalpindi and Islamabad, Pakistan.

MATERIALS AND METHODS

Study Area

The study was carried out in universities of the twin cities: the capital Islamabad and Rawalpindi. The terrain consists of plains and mountains in the metropolitan area of Islamabad and Rawalpindi, whose total area exceeds 1,175 m. In general, three general physiographic zones trend east-northeast. In the mountainous terrain of the Margalla Hills lies the northern part of the metropolitan area. Rawalpindi, famed for its ancient Buddhist heritage, is situated on the Pothohar Plateau.

Proforma Design, Study Design, Study Sample, and Study Participants

Simple random sampling was considered throughout this study and the university students and adjoining areas within the university were considered in the population, by following the (15), for the Demographic variables such as age, gender are categorical data. To assess the correct sample size formula was used. The margin of error is set to 0.05, the estimate of variance is set at 0.50, and the t-value is fixed at 1.65, which resulted in a 264-sample size. However, to overcome the non-response, initially, we set 369 sample sizes, and 31 did not provide a response. Hence, the final sample size of this study is 338 students. The study was done between July and December 2020. The proforma for data collection was designed after a thorough literature survey (4, 16, 17) and consisted of 57 questions. The questionnaire was divided into five main parts. The first part consists of 13 questions that were about the demography. The second part was about the knowledge, with 24 questions. The third, fourth, and fifth parts were about the attitude, practices, and one health with four, eight, and eight questions, respectively.

Data Collection and Analysis

The participants were briefed about the survey purposes and written informed consent was collected from the participants. Data was entered into an MS excel spread sheet and a database was established. Statistical evaluation was executed by using Jamovi version 1.6.7. One way ANOVA tests were applied to observe the scores of various factors e.g., knowledge, attitude, practices, and one health across demographic variables regarding diarrhea.

RESULTS

Socio-Demography

A total of 338 subjects participated in the study. Most of the participants were female with 63.0%, and the rest were male. Most of the participants (72.2%) were between the ages of 15–25, followed by 26–35, 36–45, and below 15 age groups. Based on ethnic groups, most of the participants were Punjabi with 52.7%, followed by Islamabadis/Islamabadians, Kashmiri, and Sindhi. Of the participants, 96.2% were Muslims while 3.8% were non-Muslims. Based on education, 43.5% participants were undergraduate students followed by graduate and intermediate. A majority (46.4%) of the income group earned below 10,000 Rs followed by participants with incomes above 30,000 Rs. monthly. A majority (70.1%) of participants were of urban origin while 29.9% were from rural backgrounds (**Table 1**).

Knowledge

Regarding knowledge about diarrhea, 75.1% of the participants knew that microorganisms were a cause of diarrhea. 52.7% of the participants knew about the microorganisms which were the cause of diarrhea and 43.5% of the respondents were aware that diarrhea is caused due to the rotavirus/norovirus or campylobacter. 50.3% of the participants knew what gastroenteritis is while 40.8% of the participants thought that

TABLE 1 | Socio demographic background of the participants.

Variable	Characteristics	Participants (No)	Frequency (%)
Age	15–25	244	72.2
	26–35	73	21.6
	36–45	16	4.7
	Below 15	5	1.5
Gender	Female	213	63.0
	Male	125	37.0
Ethnicity	Balochi	2	0.6
	Gilgiti	5	1.5
	Islamabad territory	69	20.4
	Kashmiri	44	13.0
	Pathan	11	3.3
	Punjabi	178	52.7
	Sindhi	29	8.6
Religion	Muslims	325	96.2
	Non-Muslim	13	3.8
Marital status	Married	69	20.4
	Um married	269	79.6
Qualification	Under Matric	14	4.1
	Matriculation	9	2.7
	Intermediate	22	6.5
	Undergraduate	147	43.5
	Graduate	129	38.2
	MSc	2	0.6
	Ph.D.	13	3.8
	Other	2	0.6
Occupation	Art and Design	1	0.3
	Doctor	6	1.8
	Employee in a company	43	12.7
	Engineer	14	4.1
	Housewife	1	0.3
	Lab worker	13	3.8
	Marketing	1	0.3
	Nothing	1	0.3
	Officer	9	2.7
	Other	10	3.0
	Software engineering	2	0.6
	Still a student	235	69.5
	Businessman	1	0.3
	Housewife	1	0.3
Residence	Rural	101	29.9
	Urban	237	70.1
Income per month	Below 10,000 (may include pocket money)	157	46.4
	11,000–20,000	47	13.9
	21,000–30,000	42	12.4
	Above 30,000	92	27.2
No. of family members	<5	78	23.1
	5–7	193	57.1
	7–9	62	18.3

(Continued)

TABLE 1 | Continued

Variable	Characteristics	Participants (No)	Frequency (%)
	More than 10	5	1.5
Time spends with animals (Hours per day)	0	203	60.1
	3–5	120	35.5
	6–10	13	3.8
	11–15	2	0.6
Approximate No. of animals owned	0	196	58.0
	<5	99	29.3
	6–10	36	10.7
	11–15	3	0.9
	More than 15	4	1.2
Presence of animal health care facility in the area	Yes	200	59.2
	No	46	13.6
	May be	92	27.2

gastroenteritis was an inflammation of the stomach and small intestine; 11.8% thought it was swelling of the stomach and 47.3% had no idea about the definition of gastroenteritis. 60.9% of the respondents were aware about the early symptoms of the disease while 9.5% were unaware. 69.8% of the subjects considered diarrhea to be a dangerous disease, while 47% considered it a disease that lasted for 1 week. 73% think that babies can have diarrhea, 45.3% considered weight loss to be a result of diarrhea, and 41.4% considered lethargy to be a symptom. 71.6% agreed that animals can also get diarrhea, 58.3% think that animal feces could be responsible for spreading diarrhea, and 64.2% believed that diarrhea can cause bleeding in organisms. 71.6% believed that diarrhea affects blood pressure, 92.6% responded that it may be responsible for dehydration, 54.1% believed that diarrhea can affect the baby during pregnancy, 56.8% believe in death due to this, and 55.3% considered ORS as an effective treatment for this disease. 41.4% agreed that a vaccine is available for this disease, 59.6% believed that undercooked food is responsible for diarrhea, and 83.7% believe contaminated water is a source of transmission of disease. 84.6% of the participants considered contaminated food and water a risk factor of diarrhea; 4.1% did not consider them as a risk factor and 11.2% were not sure about it. 48.2% of the participants had suffered with diarrhea while the rest of the participants had not suffered with this disease (**Table 2**).

Attitude

With respect to attitude questions, 84.6% of the participants considered visiting the doctor if they had diarrhea while 4.1% said they would not visit doctor and 11.2% were not sure about visiting. 82.5% believed that avoiding dipping their hand in a vessel could prevent diarrhea. 75.1% believed that use of filtered or boiled water should be used for consumption to avoid diarrhea and 35.2% believed that it can be transmitted form one person to another; 30.8% do not believe this and the rest of the respondents had no idea or were not sure about this (**Table 3**).

TABLE 2 | Knowledge toward diarrhea of participants in the study.

Variable	Characteristics	Participants (No)	Frequency (%)
Do you think diarrhea is an infection caused by microorganisms	Yes	254	75.1
	No	10	3.0
	May be	56	16.6
	No idea	18	5.3
Do you know about viruses and bacteria that cause diarrhea?	Yes	178	52.7
	No	111	32.8
	May be	49	14.5
Do you know Rotaviruses /Noroviruses/ Campylobacter are also a cause of diarrhea?	Yes	147	43.5
	No	70	20.7
	May be	74	21.9
	No idea	47	13.9
Do you know what gastroenteritis is	Yes	170	50.3
	No	60	17.7
	May be	55	16.3
	No idea	53	15.7
Gastroenteritis is?	Inflammation of stomach and small intestine.	138	40.8
	Swelling of stomach and small intestine.	40	11.8
	No idea	160	47.3
Do you know about the early symptoms of diarrhea	Yes	206	60.9
	No	32	9.5
	May be	94	27.8
	No idea	6	1.8
Do you think diarrhea is a dangerous disease	Yes	236	69.8
	No	19	5.6
	May be	82	24.3
	No idea	1	0.3
How many days Diarrhea lasts	1 week	159	47.0
	1–4 days	111	32.8
	2–3 weeks	19	5.6
	No idea	49	14.5
Do you think can babies have diarrhea	Yes	247	73.1
	No	16	4.7
	May be	59	17.5
	No idea	16	4.7
Consequences of diarrhea	Lethargy	140	41.4
	Loss of weight	153	45.3
	Unconsciousness	32	9.5
	Death	13	3.8
What do you think animals can get diarrhea?	Yes	242	71.6
	No	27	8.0
	Don't know	69	20.4
Do you think animal feces can spread diarrhea	Yes	197	58.3
	No	22	6.5
	May be	66	19.5
	No idea	53	15.7

(Continued)

TABLE 2 | Continued

Variable	Characteristics	Participants (No)	Frequency (%)
Can diarrhea cause bleeding	Yes	217	64.2
	No	38	11.2
	May be	54	16.0
	No idea	29	8.6
Can diarrhea affect blood pressure	Yes	242	71.6
	No	42	12.4
	No idea	54	16.0
Diarrhea can cause dehydration	Yes	313	92.6
	No	11	3.3
	No idea	14	4.1
Can diarrhea affect baby in pregnancy?	Yes	183	54.1
	No	16	4.7
	May be	100	29.6
	No idea	39	11.5
Can diarrhea cause death	Yes	192	56.8
	No	45	13.3
	May be	79	23.4
	No idea	22	6.5
Do you think ORS can be effective treatment for diarrhea?	Yes	187	55.3
	No	9	2.7
	May be	124	36.7
	No idea	18	5.3
Do you think vaccine/medicine for viruses/bacteria which cause diarrhea is available?	Yes	140	41.4
	No	20	5.9
	May be	94	27.8
	No idea	84	24.9
Can eating undercooked meat give you diarrhea?	Yes	201	59.5
	No	30	8.9
	May be	87	25.7
	No idea	20	5.9
Do you think diarrhea can be transmitted through contaminated water?	Yes	283	83.7
	No	20	5.9
	No idea	35	10.4
Is contaminated food and water consumption, a risk factor of diarrhea?	Yes	286	84.6
	No	14	4.1
	May be	38	11.2
Do you ever get infected with this disease?	Yes	163	48.2
	No	175	51.8
Does your family member get infected with this disease?	Yes	175	51.8
	No	123	36.4
	May be	40	11.8

TABLE 3 | Attitude toward diarrhea of participants in the study.

Variable	Characteristics	Participants (No)	Frequency (%)
Will you visit doctor if you are having diarrhea?	Yes	286	84.6
	No	14	4.1
	May be	38	11.2
Avoiding dipping hand in vessel	Yes	279	82.5
	No	18	5.3
	Sometimes	41	12.1
Filtering/boiling drinking water before use	Yes	254	75.1
	No	22	6.5
	Sometimes	62	18.3
Diarrhea can be transmitted from person-to-person	Yes	119	35.2
	No	104	30.8
	May be	67	19.8
	No idea	48	14.2

Practices

Regarding practices, 61.8% avoided the formation of ice from tap water while 7.4% had not used tap water for ice and 30.8% sometimes used tap water for ice at home. 87.9% considered that closing the lids of drinking water sources can prevent diarrhea. 86.7% of the participants washed their hands before cooking, eating, or after defecation, while 3.0% of responses were negative and 10.4% sometime washed their hands. 78.4% of the participants mentioned regular cleaning of drinking water vessels while 5.6% said they did not clean them regularly and 16.0% cleaned vessels but not always. 90.2% of the subjects mentioned washing fruits and vegetables before use while 1.2% thought it was not necessary to wash them and 8.6% of participants sometimes washed fruits and vegetables before use. 88.2% wash their hands before feeding their children while 9.5% practice this sometimes. 81.4% practice the proper disposal of refuse material while 74% respondents visit the doctor immediately when they encounter diarrhea (**Table 4**).

One Health

Regarding one health perspective, 85.8% of the participants knew that human health is associated with the environment while 2.1% negated it and 10.4% were not sure about it. 58.3% of the participants knew about zoonosis while 41.7% had no knowledge about it. 55.6% of the participants considered that diarrhea can be transmitted through animals while 10.4% thought it cannot be transmitted through animals and 16.6% were not sure about that. 63.6% of the participants knew about one health while 36.4% participants had no idea about one health. 33.7% of the participants mentioned that risk of diarrhea was associated with a specific age while 43.2% negated the statement and 14.8% were not sure about that. Almost more than 90% believed that there is a need for proper disposal and sewage systems, 94.1% considered that there is need for public awareness regarding this disease, and 94.1% considered that there must be awareness of complications of untreated prolonged infection (**Table 5**).

Statistical Analysis Using ANOVA

One-way ANOVA was applied to establish the relationship between dependent and independent variables. Six independent variables (age, gender, ethnicity, qualification, religion, and marital status) and four dependent variables (knowledge, attitude, practices, and one health) were taken to check their scores across all dependent and independent variables. Age and

TABLE 4 | Practices toward diarrhea of participants in the study.

Variable	Characteristics	Participants (No)	Frequency (%)
Closing the lids of drinking water source	Yes	297	87.9
	No	9	2.7
	Sometimes	32	9.5
Do you avoid ice made with tap water?	Yes	209	61.8
	No	25	7.4
	Sometimes	104	30.8
Hand wash before cooking, eating/after defecation	Yes	293	86.7
	No	10	3.0
	Sometimes	35	10.4
Regular cleaning of drinking water vessels	Yes	265	78.4
	No	19	5.6
	Sometimes	54	16.0
Washing fruits and vegetables before use	Yes	305	90.2
	No	4	1.2
	Sometimes	29	8.6
Washing hands before feeding the child	Yes	298	88.2
	No	8	2.4
	Sometimes	32	9.5
Proper disposal of reuse	Yes	275	81.4
	No	19	5.6
	Sometimes	44	13.0
Visits to doctors	Immediately visit	250	74.0
	After 2 days	67	19.8
	Never visits	21	6.2

TABLE 5 | One-health toward diarrhea of participants in the study.

Variable	Characteristics	Participants (No)	Frequency (%)
Do you think the health of humans is associated with the environment?	Yes	290	85.8
	No	07	2.1
	May be	35	10.4
	No idea	06	1.8
Do you think diarrhea can be transmitted through animals?	Yes	188	55.6
	No	35	10.4
	May be	56	16.6
	No idea	59	17.4
Do you know what zoonosis is?	Yes	197	58.3
	No	141	41.7
Do you think, the risk of diarrhea infection is associated with specific age group?	Yes	114	33.7
	No	146	43.2
	May be	50	14.8
	No idea	28	8.3
Do you know about one health?	Yes	215	63.6
	No	123	36.4
Is there any need of proper disposal and sewage systems?	Yes	305	90.2
	No	33	9.8
Is public awareness necessary to prevent infectious diseases?	Yes	318	94.1
	No	20	5.9
Should there be awareness of complications of untreated prolonged infection?	Yes	318	94.1
	No	20	5.9

ethnicity have significant association with respect to knowledge. Religion has significant association with respect to one health while education/qualification has an association with knowledge. The rest of the variables found no association with each other (**Table 6**).

DISCUSSION

The study has assessed the knowledge, attitude, practices, and one health perspective regarding diarrhea among residents of Rawalpindi/Islamabad (twin cities) of Pakistan. 83.7% of the participants were aware that diarrhea spread through contaminated water. A similar kind of study was reported from Karachi where 17% considered polluted water as a cause of diarrhea (4). One study from India reported that 55% of mothers were aware of causes of diarrhea (16). The current study was conducted among residents of twin cities where the literacy rate is highest in Pakistan. The higher literacy rate could be related to the increased knowledge about diarrhea. The contrary results from the Karachi study could be due to the limitation of the Karachi study, which was only conducted among the mothers of children under the age of 5 years (4).

Lethargy is considered as the main consequence of diarrhea. 41.4% of the participants considered lethargy a consequence of diarrhea. Similar kinds of observations were reported from Karachi; 71% of mothers said that diarrhea causes lethargy (4). Our results also showed that most of the study participants had a favorable attitude regarding diarrhea. The study showed that 55.3% of participants thought that ORS was an effective treatment for diarrhea. The same was observed in the National Family Health Survey which found that only 27% of participants use ORS in management (17). In another study from Pakistan, it was reported that 74% of mothers considered ORS as enough of a treatment for diarrhea (18).

The present study also revealed that 56.8% of the participants considered diarrhea to be a dangerous disease which can lead to the death of a person. The same observation was reported in a study from India where 81.7% people considered diarrhea a dangerous disease which can lead to death (18).

The current study reports that 81.4% of participants disposed of refuse material properly. A similar kind of study was reported from India which illustrates that 30.5% of participants disposed of waste material properly (18). The high rate of properly disposed material could be associated with higher literacy levels and people awareness in the advanced cities of Pakistan, while the low ratio from India is associated with the low literacy level in the study duration that was conducted two decades earlier (18).

According to the present survey, 86.7% of the participants washed their hands before cooking, eating, and after defecation. One study of a similar type showed that only 60% and 30%

TABLE 6 | Demographic variables across KAPs and one health using one-ANOVA.

	Knowledge ± SD	Attitude ± SD	Practices ± SD	One health ± SD
Age (in years)				
Below 15	11.00 ± 4.472	3.20 ± 0.837	7.20 ± 1.304	6.40 ± 1.140
15–25	13.02 ± 5.275	2.73 ± 1.111	6.39 ± 2.093	5.79 ± 1.681
26–35	16.55 ± 5.307	2.86 ± 1.347	6.70 ± 2.222	5.92 ± 1.631
36–45	17.38 ± 4.303	2.94 ± 1.436	6.75 ± 1.949	6.31 ± 1.138
F-test (*p*-value)	11.37 (0.001)	0.57 (0.632)	0.69 (0.556)	0.770 (0.512)
Gender				
Female	14.27 ± 5.28	2.76 ± 1.14	6.52 ± 1.99	5.91 ± 1.52
Male	13.42 ± 5.76	2.80 ± 1.24	6.43 ± 2.29	5.74 ± 1.84
F-test (*p*-value)	1.89 (0.169)	0.08 (0.767)	0.126 (0.722)	0.8118 (0.368)
Ethnicity				
Balochi	17.00 ± 5.657	3.00 ± 0.000	7.00 ± 0.000	6.50 ± 0.707
Gilgiti	14.20 ± 4.438	3.20 ± 0.447	7.60 ± 0.894	5.60 ± 1.342
Islamabad territory	13.01 ± 4.891	2.93 ± 0.896	6.88 ± 1.266	5.99 ± 1.345
Kashmiri	12.89 ± 4.696	2.70 ± 0.904	6.64 ± 1.630	5.91 ± 1.235
Pathan	10.64 ± 4.985	2.55 ± 1.128	6.09 ± 2.468	5.82 ± 1.401
Punjabi	14.80 ± 5.786	2.75 ± 1.330	6.33 ± 2.416	5.77 ± 1.868
Sindhi	13.69 ± 5.491	2.66 ± 1.289	6.17 ± 2.269	5.93 ± 1.602
F-test (*p*-value)	2.15 (0.047)	0.466 (0.833)	1.035 (0.402)	0.239 (0.963)
Religion				
Muslim	13.87 ± 5.491	2.75 ± 1.187	6.44 ± 2.130	5.80 ± 1.642
Non-Muslim	16.08 ± 4.609	3.38 ± 0.650	7.69 ± 0.480	7.00 ± 1.225
F-test (*p*-value)	2.03 (0.155)	3.65 (0.057)	4.49 (0.35)	6.75 (0.010)
Marital status				
Married	15.07 ± 5.66	2.87 ± 1.21	6.71 ± 2.08	5.78 ± 1.50
Un-married	13.67 ± 5.40	2.75 ± 1.17	6.43 ± 2.11	5.87 ± 1.68
F-test (*p*-value)	3.623 (0.058)	0.557 (0.456)	0.991 (0.320)	0.142 (0.707)
Education/Qualification				
Graduate	15.57 ± 5.805	2.71 ± 1.330	6.47 ± 2.408	5.74 ± 1.712
Intermediate	11.36 ± 4.424	2.64 ± 0.953	6.55 ± 1.299	5.73 ± 1.352
Matriculation	9.89 ± 3.100	2.89 ± 0.782	7.00 ± 1.000	5.78 ± 0.833
Msc	9.00 ± 0.000	2.00 ± 0.000	7.00 ± 0.000	6.00 ± 0.000
Other	9.50 ± 3.536	2.50 ± 0.707	6.50 ± 0.707	5.50 ± 0.707
Ph.D.	18.69 ± 3.591	2.77 ± 1.787	6.23 ± 2.619	6.38 ± 1.502
Under Matric	10.29 ± 2.585	2.64 ± 1.008	5.86 ± 2.143	5.29 ± 1.939
Undergraduate	13.24 ± 5.067	2.87 ± 1.049	6.54 ± 1.949	5.98 ± 1.657
F-test (*p*-value)	6.84 (0.001)	0.40 (0.899)	0.31 (0.948)	0.682 (0.687)

practiced handwashing after defecation and before handling of food, respectively (16). In another study from Karachi, it was reported that 62% of mothers understand the different preventive strategies such as washing hands and keeping the room and the child clean as far as diarrhea prevention was concerned (4).

Statistical analysis showed that age is associated significantly with knowledge and attitude. This may mean that knowledge and attitudes vary with age. Furthermore, knowledge, practices, and one health were associated with religion significantly. This may mean that religion has a major influence on the current knowledge, practices, and one health. Education was also found to be associated with knowledge. The rest of the parameters have no significant association with one another. Our results were in line with a KAPS study from Pakistan (19) and is contrary to the study by Khan et al. (20), suggesting that every disease has their own demographic attributes.

CONCLUSION

It is concluded from this study that most residents of the twin cities of Pakistan knew about diarrhea and had a good attitude and practices toward it. Age, religion, and education have different roles regarding different diseases in the population of Pakistan. The current study has its limitations as well. Parts of the study was conducted in the capital of Pakistan which is more developed as compared to other areas of Pakistan. It would be better to explore the remote areas of Pakistan where basic amenities of life such as education, wealth, and

employment are not available. To raise awareness among those people, we should convey our messages by means of social media, seminars, and motivational talks. In addition to all these things, education, basic amenities, and health facilities should be provided across Pakistan.

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 ERB of COMSATS University Islamabad under CUI/Bio/ERB/2021/50 approval number. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AA collected the data. RS and AA wrote the paper. MA and HZ performed the statistical analysis. The study was designed and supervised by KS and HA. RS, HA, TZ, and JC critically revised the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This study was supported by the National Natural Science Foundation of China (No. 81772225 to JC), the Laboratory of Parasite and Vector Biology, National Health Commission of People's Republic of China (No. WSBKFKT2017-01 to AA), and the Fifth Round of Three-Year Public Health Action Plan of Shanghai (No. GWV-10.1-XK13 to JC). The funders had no role in the study design, the data collection and analysis, the decision to publish, or the preparation of the manuscript.

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frontiers in Public Health

OPINION
published: 17 December 2021
doi: 10.3389/fpubh.2021.770593

Post COVID Antimicrobial Resistance Threat in Lower- and Middle-Income Countries: Bangladesh

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Keywords: COVID-19, antimicrobial resistance (AMR), lower middle income countries (LMICs), Bangladesh, Post COVID

COVID-19, a global pandemic, has put enormous strain on the world's health care systems. One of the most serious issues that clinicians and researchers confront is a lack of effective and easily available COVID-19 treatment possibilities. COVID-19 brought to light the perilous state of our healthcare systems, which had previously flown under the radar from other sectors. This is especially true in low- and middle-income countries (LMICs) and resource-constrained settings, which are less prepared to deal with pandemics or other disasters. Due to lack of knowledge and treatment options for dealing with pandemic in those countries, several antimicrobial medicines are now being used by healthcare workers to treat SARS-CoV-2. Antibiotic overuse and misuse in the treatment of COVID may contribute to the establishment of antimicrobial resistance (AMR). It has the potential to be the next global health disaster, and it has already had an impact on the action to Covid-19 (1–3).

Access to effective antimicrobials is largely unavailable in LMICs, while rates of AMR are expected to expand 4–7 times faster (4). Additionally, because of high rates of improper antibiotic prescribing for COVID-19 patients, treatment interruptions for persons with chronic illness, and broad use of antimicrobial drugs by local populations, COVID-19 has most possibly increased the rate of AMR-related consequences (5).

The lack of awareness about disease outbreaks, misconceptions regarding coronavirus, and social and cultural stigma surrounding the virus have generated a murky dread among the general public throughout the country. As a result, the majority of individuals are frightened of testing positive for coronavirus. When people have COVID-like symptoms, they frequently take self-prescribe antimicrobials such as azithromycin, doxycycline, moxifloxacin, ivermectin, and even specialized experimental medicines from local pharmacies and quacks without seeing physicians and disregarding their possibly harmful side effects. During this SARS-CoV-2 virus outbreak, disinformation on social media about COVID-19, and the availability of treatment prescriptions on numerous Facebook groups encourage individuals to use antibiotics without fully comprehending the dangers. These factors are frequently linked to the misuse of antibiotics during the pandemic (6, 7).

If we analyze the antibiotic prescription rate in Bangladesh, we find that illogical antibiotic prescribing and consumption are highly prevalent among COVID-19 positive individuals in Bangladesh. One study evaluated the antibiotic prescribing rate among SARS-CoV-2 positive patients at a Bangladeshi tertiary COVID-19-dedicated hospital. The findings indicate that 100% of hospitalized patients were getting at least one antibiotic. Antibiotics were prescribed more frequently to individuals with severe illness in general. Ceftriaxone (53.8%), meropenem (40.9%), moxifloxacin (29.5%), and doxycycline (25.4%) were the four most frequently given antibiotics among hospitalized SARS-CoV-2 positive patients (8).

OPEN ACCESS

Edited by:
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University of Belgrade, Serbia

Reviewed by:
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Jahangirnagar University, Bangladesh
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Specialty section:
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

Received: *04 September 2021*
Accepted: *29 November 2021*
Published: *17 December 2021*

Citation:
Mahadi AR (2021) Post COVID Antimicrobial Resistance Threat in Lower- and Middle-Income Countries: Bangladesh. Front. Public Health 9:770593. doi: 10.3389/fpubh.2021.770593

Another study conducted in Bangladesh found that antimicrobial drugs use patterns are significantly high. Cephalosporin, third-generation cephalosporin, macrolide, and azithromycin were the most frequently reported antibiotic classes (9).

A large number of people in our country, regardless of socio-economic status and education, do not consult a registered physician prior to initiating an antibiotic course, frequently relying on retail drugstore's advice. Bangladesh is considered to have a high rate of self-medication since most drugs can be accessed without a prescription from local pharmacies. People can obtain antimicrobials drugs without a prescription from those pharmacies, even in the most distant areas of the region (10).

During the COVID-19 epidemic, this self-medication behavior increased up to 88%. Self-medication for symptoms such as SARS-CoV-2 without doing a COVID-19 test was found to be widespread in Bangladesh during the pandemic period where ivermectin (77%) and azithromycin (54%) were the most commonly self-medicated medicines during the COVID-19 pandemic time (11).

Due to overuse of antibiotics during the pandemic, some drugs might have lost their efficacy against certain specific microbes. Since no new antibiotics are presently being developed for prospective use, the extant antibiotics are losing efficacy, which might have disastrous consequences in the near future. Increasing rates of antibiotic resistance will leave doctors with fewer medication alternatives to manage microbial infectious diseases in the coming years. Misuse of antibiotics will exacerbate the resistance rate and it will be a significant challenge for humanity to overcome (12).

The data of COVID-19 should be used to support future research policies aimed at preventing a future AMR pandemic, which is mainly characterized as a slow-emerging catastrophe which may become more destructive than COVID-19.

In conclusion, lower-middle income countries are at significant risk of future antimicrobial resistance disasters. During this pandemic era, we are nearly disregarding this issue in those countries that are on the verge of a calamity. We will not be able to really address the AMR problem in the world until we develop strong legislation and raise awareness in those countries. To address the rising threat of antimicrobial resistance during this pandemic phase, urgent suitable interventions and preventative measures should be developed from the ground up after identifying the real occurrence and rate of antimicrobial misuse in lower- and middle-income countries including Bangladesh during the COVID-19 pandemic. Additionally, it is essential to implement a surveillance system for antimicrobial medication prescriptions, as well as more strictly enforced sales controls.

AUTHOR CONTRIBUTIONS

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

ACKNOWLEDGMENTS

Special gratitude to my mentors Dr. Tasdik Hasan Dip and Dr. Abdur Rafi for always encouraging me to write.

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frontiers in Public Health

REVIEW
published: 20 January 2022
doi: 10.3389/fpubh.2021.755285

Addressing Inequalities Toward Inclusive Governance for Achieving One Health: A Rapid Review

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Sustainable development goals (SDGs) adopted in 2015 are geared toward sustainable development through various pathways, one being reducing inequality as covered in SDG 10. Inequalities are a threat to health and wellbeing of populations and a planet Earth in which we live. This rapid review aims to identify key issues that are likely to exacerbate inequalities around the six SDGs directly related to One Health, which are SDG 3, 6, 11, 13, 14 and 15, and suggest some actions that may help to address them using inclusive governance taking into account the coronavirus disease of 2019 (COVID-19) pandemic. Informed by the literature on SDGs and using the "*inclusive development concept*" by Gupta and Vegelin, literature search was done in Google Scholar, PubMed Central, as well as, searching of references in the relevant articles identified using search terms from the six SDGs that are directly related to One Health. In the context of the SDGs, in order to achieve One Health through inclusive governance, and tackle inequalities, the following needs to be considered and addressed: increasing number of armed conflicts; ongoing COVID-19 pandemic; ensuring availability of water and sanitation facilities; improving city and urban areas planning to cope with climate change; improving governance arrangements for addressing climate change factoring gender and human rights; multisectoral planning for conservation of oceans, seas, and marine resources; balancing trade regulation of wildlife trade with conservation efforts; need for a research collaborative involving experts from environmental sciences, wildlife, agriculture and human health to study and develop scientific evidence on contribution of changes in land use practices to occurrence of zoonotic diseases; and need of a legislation for promoting animal welfare to protect public health. Also, inclusion of people with disabilities in the use of digital technologies is critical.

Keywords: inequality, One Health (OH)-approach, Sustainable Development Goals, COVID-19, climate change, inclusive governance, inclusive development, zoonotic diseases

Edited by:
Ulrich Laaser, Bielefeld University, Germany

Reviewed by:
Xiaobo Liu, National Institute for Communicable Disease Control and Prevention (China CDC), China
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Specialty section:
This article was submitted to Environmental health and Exposome, a section of the journal Frontiers in Public Health

Received: *08 August 2021*
Accepted: *27 December 2021*
Published: *20 January 2022*

Citation:
Eliakimu ES and Mans L (2022) Addressing Inequalities Toward Inclusive Governance for Achieving One Health: A Rapid Review. Front. Public Health 9:755285. doi: 10.3389/fpubh.2021.755285

INTRODUCTION

The United Nations agenda for sustainable development to transform our world by 2030, articulated the 17 Sustainable Development Goals (SDGs). Targets for the SDG 10 which aims to "*reduce inequality within and among countries*" focus on five key actions areas as follows: income inequality and growth; financial and trade issues; migration; social, economic and political

inclusion of all; and representation and voice of developing countries in global international economic and financial institutions (1). Six of the 17 SDGs are related to One Health directly, which are SDG3-*ensure healthy lives and promote well-being for all at all ages*; SDG 6-*ensure availability and sustainable management of water and sanitation for all*; SDG11- *make cities and human settlements inclusive, safe, resilient and sustainable*; SDG13-*take urgent action to combat climate change and its impacts*; SDG14-*conserve and sustainably use the oceans, seas and marine resources for sustainable development*; and SDG15-*protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss* (1, 2).

The progress made in the implementation of the SDGs since their adoption in 2015 has decreased in 2020 due to "*a decline driven to a large extent by increased poverty rates and unemployment following the outbreak of the COVID-19 pandemic; which has impacted all three dimensions of sustainable development: economic, social, and environmental*" (3). One Health approach defined as "*a collaborative, multisectoral, and transdisciplinary approach—working at the local, regional, national, and global levels—with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment;*"(4) is an important avenue for ensuring that the world we leave is safe and healthy. To achieve this aim requires taking a governance approach that addresses the needs of and takes everyone on board (i.e., inclusive governance).

The "*inclusive development concept*" by Gupta and Vegelin (5) connected with the work by Veronica Ormea (2) provides a useful framework for analyzing drivers of inequalities that can be addressed within the lens of inclusive governance toward One Health withing the SDGs era and beyond. Therefore, this rapid review aims to analyze key drivers of inequalities around the six SDGs directly related to One Health and suggest some actions that may help to address it using inclusive governance taking into account the coronavirus disease of 2019 (COVID-19) pandemic.

METHODS

Informed by the literature on SDGs and using the "*inclusive development concept*" by Gupta and Vegelin (5), literature search for this rapid review was done using the search terms from the six SDGs that are directly related to One Health. Searches were done in Google Scholar, PubMed Central (from 07th to 13th July 2021), as well as, searching of references in the relevant articles published in the last five years (2017–2021) and identified using the following search terms: climate change; inequality and climate change; sustainable cities; inequality in availability of water and sanitation facilities; sustainable use of oceans, seas and marine resources; land degradation and biodiversity loss; sustainable use of terrestrial ecosystems; inequality in health and well-being. One of the authors (ESE) did the first round of literature search, qualitative data extraction, and drafted the results. Then, shared with the co-author (LM) who independently read the paper and looked at the data extraction for relevance and improvements/modifications. Where there were differences the two authors discussed and reached consensus on the best result.

RESULTS

The initial literature search obtained 35 relevant papers to the study aim; and in subsequent revision of the manuscript, three references were added making a total of 38 papers. **Table 1** shows the details of the papers and the SDGs that are addressed by the papers.

Key drivers of inequality are presented as per the six SDGs that are directly related to One Health.

Ensure Healthy Lives and Promote Well-Being for All at All Ages

As we move forward with the SDGs era, armed conflicts continue to affect various countries in various regions globally affecting health and well-being of populations involved. For instance, in 2020 there were 56 active conflicts of which eight were wars, an increase from seven wars in 2019 and six wars in 2018 (6). Conflicts also affect coverage of health interventions to vulnerable populations especially women, children and adolescents leading to health inequalities in conflict affected countries compared to countries without conflicts (7).

The current COVID-19 pandemic has worsened the health and well-being of global populations in many ways including a high mortality, in which as per the World Health Organization (WHO) COVID-19 dashboard "*as of 2:24pm CEST, 13 July 2021: there have been 186,821,815 confirmed cases of COVID-19, including 4,038,342 deaths, reported to WHO*" (44). The COVID-19 has been shown to exacerbate inequalities even in high income countries with racial disparities in outcomes, which calls for a more research to gain an insight on what makes such inequalities to continue so that the world can better prepare for future pandemics as well as addressing the gaps in the ongoing pandemic (8). The epidemiological role of discrimination is found to be important. Cuevas et al. show that experiences of discrimination, both acute and chronic, can dysregulate immune function, characterized by elevated levels of inflammation, i.e., worsening people's health and well-being (9). Also, the COVID-19 pandemic is likely to add more burden to countries with high burden of Human Immunodeficiency Virus (HIV) infections in terms of social and psychological factors. In this case it requires more attention employing the "*syndemic approach*" in order to uncover vulnerabilities and design relevant strategies to protect the affected populations (10, 11). The pandemic has also impacted on the global supply chain for health commodities in an unprecedented way. In order to support low-and middle- income countries (LMICs) especially those in the African continent in a way that will ensure availability of essential health commodities that will ensure continuity of essential services and address the needs for care of COVID-19 patients, it has been proposed that support need to be informed by data on "*comparative risk assessment*" (12).

TABLE 1 | Retrieved literature.

References	Study Title	SDGs addressed
Strand and Hegre (6)	Trends in Armed Conflict, 1946–2020.	Ensure healthy lives and promote well-being for all at all ages
Akseer et al. (7)	Women, children and adolescents in conflict countries: an assessment of inequalities in intervention coverage and survival.	
Dickinson et al. (8)	Structural Racism and the COVID-19 Experience in the United States.	
Cuevas et al. (9)	Discrimination and systemic inflammation: A critical review and synthesis.	
Shiau et al. (10)	The Burden of COVID-19 in People Living with HIV: A Syndemic Perspective.	
Singer et al. (11)	Syndemics and the biosocial conception of health.	
Amimo et al. (12)	A review of prospective pathways and impacts of COVID-19 on the accessibility, safety, quality, and affordability of essential medicines and vaccines for universal health coverage in Africa.	
Shankar-Hari et al. (13)	Association Between Administration of IL-6 Antagonists and Mortality Among Patients Hospitalized for COVID-19: A Meta-analysis.	
Cullinan (14)	Finally, Therapeutics for Severe COVID-19 – But They Come With Hefty Price Tags.	
Cullinan (15)	Roche Suspends Patents on Tocilizumab in LMICs After WHO Recommends it as Treatment for Severe COVID-19.	
Local Burden of Disease WaSH Collaborators (16)	Mapping geographical inequalities in access to drinking water and sanitation facilities in low-income and middle-income countries, 2000-17.	Ensure availability and sustainable management of water and sanitation for all
Gwenzi (17)	Leaving no stone unturned in light of the COVID-19 fecal-oral hypothesis? A water, sanitation and hygiene (WASH) perspective targeting low-income countries.	
Hobbie and Grimm (18)	Nature-based approaches to managing climate change impacts in cities.	Make cities and human settlements inclusive, safe, resilient and sustainable
Lin et al. (19)	Integrating solutions to adapt cities for climate change.	
Yahia et al. (20)	Effect of urban design on microclimate and thermal comfort outdoors in warm-humid Dar es Salaam, Tanzania.	
Seddon et al. (21)	Understanding the value and limits of nature-based solutions to climate change and other global challenges.	
Patel (22)	Preventing COVID-19 Amid Public Health and Urban Planning Failures in Slums of Indian Cities.	
Lloyd et al. (23)	A Global-Level Model of the Potential Impacts of Climate Change on Child Stunting via Income and Food Price in 2030.	Take urgent action to combat climate change and its impacts
Janssens et al. (24)	Global hunger and climate change adaptation through international trade.	
Andrijevic et al. (25)	Overcoming gender inequality for climate resilient development.	
Aryal et al. (26)	Climate risks and adaptation strategies of farmers in East Africa and South Asia.	
Talukder et al. (27)	Health impacts of climate change on smallholder farmers.	
Bezgrebelna et al. (28)	Climate Change, Weather, Housing Precarity, and Homelessness: A Systematic Review of Reviews.	
Baker et al. (29)	Infectious disease in an era of global change.	
Beyer et al. (30)	Shifts in global bat diversity suggest a possible role of climate change in the emergence of SARS-CoV-1 and SARS-CoV-2.	
Rocque et al. (31)	Health effects of climate change: an overview of systematic reviews.	
Bruno et al. (32)	Climate change threatens the world's marine protected areas.	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Carr et al. (33)	The Aichi Biodiversity Targets: achievements for marine conservation and priorities beyond 2020.	
Grip and Blomqvist (34)	Marine spatial planning: Coordinating divergent marine interests.	

(Continued)

TABLE 1 | Continued

References	Study Title	SDGs addressed
Aguirre et al. (35)	Illicit Wildlife Trade, Wet Markets, and COVID-19: Preventing Future Pandemics.	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Morcatty et al. (36)	Online trade in wildlife and the lack of response to COVID-19.	
Shivaprakash et al. (37)	Mammals, wildlife trade, and the next global pandemic.	
Roe et al. (38)	Beyond banning wildlife trade: COVID-19, conservation and development.	
McNamara et al. (39)	COVID-19, Systemic Crisis, and Possible Implications for the Wild Meat Trade in Sub-Saharan Africa.	
Wikramanayake et al. (40)	Evaluating wildlife markets for pandemic disease risk.	
Wikramanayake et al. (41)	A tool for rapid assessment of wildlife markets in the Asia-Pacific Region for risk of future zoonotic disease outbreaks.	
Plowright et al. (42)	Land use-induced spillover: a call to action to safeguard environmental, animal, and human health.	
Whitfort (43)	COVID-19 and Wildlife Farming in China: Legislating to Protect Wild Animal Health and Welfare in the Wake of a Global Pandemic.	

Apart from great efforts in the area of research and innovation to combat the COVID-19 pandemic, global, regional and country cooperation and solidarity efforts are needed to enable deployment of discoveries to save lives of people who need them. For instance, in a recent meta-analysis of 27 trials which "assessed the efficacy of Iterleukin-6 (IL-6) antagonists in patients hospitalized for COVID-19," it was found that "administration of IL-6 antagonists (Tocilizumab and Sarilumab), compared with usual care or placebo, was associated with lower 28-day all-cause mortality" (13). The World Health Organization (WHO) immediately (on 06th July 2021) went on to recommend the use of the medicines for COVID-19 patients; however, the biggest challenge to health systems in low-and middle- income countries (LMICs) is a high price of the medicines (14). This means that high income countries and international organizations must find ways that will ensure the medicines are accessible to poor countries in which the number of COVID-19 cases and deaths is increasing and also, they lack access to COVID-19 vaccines. In signs of enhanced commitment to save human life, the Swiss pharmaceutical company Roche (a day after WHO recommended the use of the medicines) announced that it has suspended its patent rights on the medication tocilizumab in LMICs for the duration of the pandemic, an action that will contribute to its accessibility to people in need in LMICs (15). Therefore, other manufacturing companies and high-income countries should also do the same to support LMICs to access the live saving health commodities including the COVID-19 vaccines.

Ensure Availability and Sustainable Management of Water and Sanitation for All

Availability of water and sanitation facilities in LMICs has increased in the past two decades, however inequalities in access still persist at subnational levels with more access in urban areas (16). Concerted efforts to address this inequality in access to water and sanitation facilities are needed given the ongoing COVID-19 pandemic (17).

Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable

Cities in LMICs are growing rapidly and due to inadequate resources, they are inadequately prepared to handle effects of climate change. Implementation of nature-based solutions have been shown to have potential for improving living conditions in cities (18); and in particular due to the fact that they are low cost and widely accessible (19). A study that assessed the effect of urban design in relation to the nature-based solutions in Dar es Salaam, Tanzania, provided some insights that can be used to improve living conditions and address effects of climate change which require city planners and architects to take them on board; an indication of how inclusive we should be in terms of expertise involvement if we are to achieve One Health and be able to tackle such global health challenges as climate change (20). In order to realize the full potential of nature-based solutions, there is a need for further research and to ensure that its implementation take into account a systems-thinking framework (21). Also, inadequate planning of cities in LMICs as manifested by people living in slum areas affects implementation of interventions to improve well-being of the people. The challenges observed in addressing the ongoing COVID-19 pandemic are further enlightening us on the need for improving planning of cities and other urban areas in order to allow implementation of public health measures necessary for combating the current and future epidemics (22).

Take Urgent Action to Combat Climate Change and Its Impacts

The threat of climate change to the world we live are many, hence, threatening our health and well-being. Effects of climate

change to the nutrition of children under 5 years are likely to be greater in rural areas in which income of the people and prices of food are likely to affect availability of food to children (23). Also, climate change affects food accessibility to populations and exacerbates poverty and inequality. In addressing the challenge of famine, adaptation using adjustments in international trade such as reducing tariffs and barriers at organizational level as well as infrastructural barriers have been shown to have potential for addressing food shortages (24). Along these efforts, in order to address inequalities and ensure inclusiveness, there is a need for ensuring that gender equality is part and parcel of the interventions to address effects of climate change (25). Also, small-scale farmers are affected by climate change. For example, a study by Aryal and colleagues, has reported effects of climate risks to farmers in East Africa and South Asia in which they found an inadequate capacity to deal with effects of climate change which was further compromised with inadequate governance (26). Health effects of climate change to small-scale farmers have been reported to range from "*communicable diseases; non-communicable diseases; mental health; and occupational health, safety and other health issues*" (27). These effects require actions to be taken at country level and global level (27). Taking into account that climate change also affects disproportionately people without housing, Bezgrebelna and colleagues have suggested for application of a "*Human Rights-Based Approach*" in designing of interventions to address this situation (28). We note that health impacts of climate change are enormous and may increase as global warming continues. According to Baker et al. climate change, rapid urbanization and changing land-use patterns will increase the risk of disease emergence in the coming decades. Climate change, in particular, may alter the range of global pathogens, allowing infections, particularly vector-borne infections, to expand into new locations (29). Climate change may have played a key role in the evolution or transmission of SARS-CoV-1 and SARS-CoV-2 (30). Therefore, it is important to continue researching on its dynamics so that we can understand vulnerabilities and hence address the inequalities resulting from its effects (31).

Conserve and Sustainably Use the Oceans, Seas and Marine Resources for Sustainable Development

Sustainability of oceans, seas and marine resources continues to be affected by climate change, and if the global efforts to address climate change are not effectively harnessed, effects of climate change will be huge by 2050 (32). With the economic role attached to these resources by countries and populations, it is extremely important now to take collective actions that will improve conservation interventions for our current and future well-being (33). In planning process for addressing these challenges, the "*Marine spatial planning*" as described by Grip and Blomqvist, offers a multisectoral planning process "*for coordinating different marine interests and balancing the use, protection and conservation of marine areas and space with its resources, biodiversity and ecosystem services*" (34). By multisectoral planning, it will ensure that the needs of those who depend on marine resources for their livelihood are taken into account.

Protect, Restore and Promote Sustainable Use of Terrestrial Ecosystems, Sustainably Manage Forests, Combat Desertification, and Halt and Reverse Land Degradation and Halt Biodiversity Loss

As part of addressing the COVID-19 pandemic, need for considering control of business of live wild animals and also eating practices in terms of regulating wildlife markets was noted (35, 36). However, researchers have suggested that wildlife trade is a source of income for the poor people therefore indiscriminate banning may exacerbate poverty and may also not be sustainable in the longer term in addressing risk of zoonotic diseases to humans. Therefore, balancing trade regulation with conservation efforts will be a better approach to allow those who depend on it to earn their living and to contribute to their economic development (37–39). In order to better address this, it has been suggested to find ways of assessing the markets for risk of transmission (37, 40). Wikramanayake and colleagues have developed a tool based on the situation in the South East Asia which can be used for this purpose and probably applicable to other global regions as well (40, 41). The need to complement such regulatory efforts with strategies to improve use of land in order to minimize spread of zoonotic diseases from animals to humans has been emphasized (42). Plowright and colleagues have called for a collaborative effort involving experts from environmental sciences, wildlife, agriculture and human health to study and develop scientific evidence on contribution of changes in land use practices to occurrence of zoonotic diseases (42). Also, the authors have pointed out that findings from such collaborative research on land use will "*help to understand and show how investments in landscape conservation provide returns for human health, climate change, international trade, sustainable development, environmental justice, and other policy issues associated with human well-being*" (42). The debate about the origin of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19, has reminded us about the health and welfare of animals. A paper by Whitfort has described the gaps in China in terms of the lack of a legislation for promoting animal welfare, which is key in protecting public health, and that moving forward "*decisions about animal welfare law and policy require a global vision*" (43).

DISCUSSION

In the context of the SDGs, in order to achieve One Health through inclusive governance, and tackle inequalities, the following need to be addressed: armed conflicts; ongoing COVID-19 pandemic; availability of water and sanitation facilities; improving city and urban areas planning; improving governance arrangements for addressing effects of climate change factoring gender and human rights; multisectoral planning for conservation of marine resources; balancing trade regulation wildlife trade with conservation efforts; research

collaborative involving experts from environmental sciences, wildlife, agriculture and human health to study and develop scientific evidence on contribution of changes in land use practices to occurrence of zoonotic diseases; and need for a legislation for promoting animal welfare to protect public health.

As Sachs and colleagues have put it clearly in the SDGs report of 2021, "*digital technologies have played a critical role in sustaining social services, payments, schooling, and health care during the lockdowns, and in enabling working from home to be effective for many occupations. The importance of digital applications underscores the vital importance of universal access to broadband services as key to social inclusion, economic opportunity, and public health*"(3). However, currently there is no adequate research evidence about digital technologies and disability that will allow inclusion and participation of people with disabilities in the digital era (45). Strengthening research in this area is of paramount importance in order to ensure that people with disabilities are not sidelined in the digital revolution. Having research evidence that is contextualized to country context is critical, taking example of the study by Lin and colleagues in China (46). Also, there is a need to delve further into the interplay between power and inequalities taking into account sources, and forms of power in people's everyday life (47).

In order to achieve health and well-being in the context of SDGs improving accountability and human rights is imperative (48). The efforts to protect the nature from human destruction requires governments to: ensure financial resources reach the local people; take into account human rights issues; and involve local people in conservation efforts and fostering partnerships with stakeholders (38). Moving forward, there is also a need to strengthen country capacities (with global coordination) for conducting research on health inequalities (49).

In terms of addressing risk of zoonotic diseases epidemics and pandemics, multisectoral collaboration is essential. As also stated in the "tripartite zoonoses guide" (50), that countries need to strengthen *"multisectoral communication, coordination, and collaboration*" in order to better address current and future pandemics from zoonotic pathogens. A proposal by Frieden and colleagues on a measure aiming at instituting accountability in handling outbreaks offers an avenue of accountability at country level and global level to avoid future effects we are witnessing currently with the COVID-19 pandemic. The proposed measure has a target of "detection within 7 days; notification, investigation, and initiation of response within 1 day; and establishing effective control measures within 7 days" (51). As, put forward by Weible and colleagues, such issues that are at a level of a global policy challenge such as COVID-19 deserves to be addressed through *"transnational administration"* (52).

CONCLUSION

Inequalities affect health and well-being of populations globally, regionally and at country level. Inclusive approach to governance is a potential way to take onboard everyone and hence reduce inequalities. The ongoing COVID-19 pandemic has exacerbated inequality and its drivers, hence, threatening to strain our efforts to address inequalities through One Health approach. While, we have identified some key strategies to address inequalities in relation to the six SDGs directly related to One Health, they will need to be supported by strong policies at global, regional and country level learning from policy sciences. It also requires strengthened country capacities for conducting research on health inequalities. We therefore, call for inclusive governance in addressing inequalities to achieve One Health.

AUTHOR CONTRIBUTIONS

EE conceptualized the manuscript, wrote the first draft of the manuscript, and contributed to review of the subsequent versions of the manuscript. LM contributed to the writing of the manuscript and review of the manuscript. Both authors have read 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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frontiers in Public Health

ORIGINAL RESEARCH
published: 24 February 2022
doi: 10.3389/fpubh.2022.830893

Participation in One Health Networks and Involvement in the COVID-19 Pandemic Response: A Global Study

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OPEN ACCESS

Edited by:
Richard Seifman, United Nations Educational, Scientific and Cultural Organization, Italy

Reviewed by:
Janko Jankovic, University of Belgrade, Serbia
Rohini Roopnarine, St George's University, Grenada

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Specialty section:
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

Received: *07 December 2021*
Accepted: *14 January 2022*
Published: *24 February 2022*

Citation:
Streichert LC, Sepe LP, Jokelainen P, Stroud CM, Berezowski J and Del Rio Vilas VJ (2022) Participation in One Health Networks and Involvement in the COVID-19 Pandemic Response: A Global Study. Front. Public Health 10:830893. doi: 10.3389/fpubh.2022.830893

The COVID-19 pandemic exemplifies a One Health issue at the intersection of human, animal, and environmental health that requires collaboration across sectors to manage it successfully. The global One Health community includes professionals working in many different fields including human medicine, veterinary medicine, public health, ecosystem health, and, increasingly, social sciences. The aims of this cross-sectional study were to describe the involvement of the global One Health community in COVID-19 pandemic response activities. One Health networks (OHNs) have formed globally to serve professionals with common interests in collaborative approaches. We assessed the potential association between being part of an OHN and involvement in COVID-19 response activities. Data were collected in July-August 2020 using an online questionnaire that addressed work characteristics, perceived connection to OHNs, involvement in COVID-19 pandemic response activities, and barriers and facilitators to the involvement. The sample included 1,050 respondents from 94 countries across a range of organizations and work sectors including, but not restricted to, those typically associated with a One Health approach. Sixty-four percent of survey respondents indicated involvement in pandemic response activities. Being part of an OHN was positively associated with being involved in the COVID-19 response (odds ratio: 1.8, 95% confidence interval: 1.3–2.4). Lack of opportunities was a commonly reported barrier to involvement globally, with lack of funding the largest barrier in the WHO African region. This insight into diverse workforce involvement in the pandemic helps fill a gap in the global health workforce and public health education literature. An expanded understanding of the perceived roles and value of OHNs can inform targeted interventions to improve public health education and workforce capacity to prepare for and respond to public health emergencies.

Keywords: SARS-CoV-2, One Health, network, multisectoral, pandemic response, capacity-building

INTRODUCTION

The COVID-19 pandemic is a complex issue that has affected almost every aspect of life worldwide (1, 2). It has led to the mobilization of a public health workforce and to community engagement campaigns in diverse contexts around the globe. Managing the pandemic requires strategies that facilitate communication and coordinate action across sectors and disciplines. One Health is an operational framework that takes an integrated, multisectoral, and transdisciplinary perspective, with a focus on the links between animal, human, and environmental health systems (3). The COVID-19 pandemic is considered a One Health issue because of its complexity and the zoonotic nature of the coronavirus SARS-CoV-2 (4–6).

The need for a coordinated One Health approach to mitigate and address pandemic risks, including COVID-19, has been embraced by leading international policy organizations, including the Tripartite made up of the World Health Organization (WHO), the World Organisation for Animal Health (OIE), and the Food and Agriculture Organization of the United Nations (FAO) (7); the United Nations Environment Programme (UNEP) (8); the World Bank (9–11); and others (12–14). The release of a working definition for One Health with joint Tripartite and UNEP support demonstrates the momentum for operationalizing coordinated One Health approaches at multiple levels in the international arena (3). While there has been extensive rhetoric supporting the One Health concept and approach during the current pandemic, the impact of One Health networks on the extent of multisectoral workforce response to the COVID-19 pandemic has not been investigated on a global scale.

The proof of concept for the utility of One Health has been demonstrated repeatedly during previous outbreaks of zoonotic diseases (13, 15–17). The key messages from One Health actions reported during COVID-19 include the importance of a supportive environment with shared resources, interdisciplinary engagement, and strategies for communication networks (18, 19). To perform effectively, professionals need to be armed with the knowledge and skills from their own discipline, and also to be motivated and able to bridge with others (20). Proficiency in competencies required for understanding and applying One Health concepts requires breaking down disciplinary and professional siloes to find areas of overlap and complementarity (21–24).

Worldwide, One Health networks (OHNs) play a role in operationalizing One Health by providing information sharing, professional development, and opportunities for collaboration across disciplines (25–27). In April 2020, the WHO Global Outreach and Response Network (GOARN), in partnership with the One Health Commission (OHC) and the One Health European Joint Programme (One Health EJP), issued a COVID-19 Call to Action seeking experts in One Health to assist during the pandemic (28). The rapid response to the call from over 600 professionals working in anthropology, medicine, epidemiology, veterinary care, wildlife, public health, ecohealth, and other disciplines demonstrated the potential of OHNs to reach and mobilize a diverse workforce. It also highlighted the need for more research to evaluate the outcomes and impacts of OHNs.

While the application of One Health approaches has been evaluated in a number of contexts (29–31), there has been relatively little assessment of the impact of OHNs or factors that support workforce efforts to operationalize One Health (19, 32–34). The aims of this study were to describe the involvement of a cross-section of the global One Health community in the COVID-19 pandemic response, to discern the barriers and facilitators that influenced that involvement, and to elucidate any connection between being associated with an OHN and involvement in COVID-19 response activities. This is the first study to examine the reach and impact of OHNs as determined by primary data across multiple contexts and, therefore, has relevance for many different audiences, including the general public.

MATERIALS AND METHODS

Study Design and Recruitment

We conducted a questionnaire-based descriptive study and report the work and its results following the STROBE checklist for cross-sectional studies (35) (**Supplementary Material 1**). The questionnaire was administered using an online survey tool (Survey Monkey), with no restrictions to respondents. The survey link was distributed broadly through OHN listservs, social media, and to over 100 previously identified OHNs (25), with a request to distribute it beyond the OHNs. The survey link was open from 15 July 2020 to 21 August 2020.

Questionnaire

The English-only questionnaire (**Supplementary Material 2**) was piloted with a group of individuals from different sectors (human medicine, public health, animal health) and types of organizations (academic, non-profit), and revised to ensure clarity and consistency before its launch. The questions and response options were developed based on previous work on the topic (25) and the experience of the diverse, multidisciplinary project team (20). A definition for One Health was provided in the introduction of the survey instrument. The sixteen questions covered selected key work-related characteristics of the respondent; self-reported connection with an OHN and participation in OHN activities; self-reported involvement in COVID-19 response; skills applied and activities conducted as part of the pandemic response, if applicable; and perceived barriers and facilitators to involvement in the COVID-19 response.

As OHNs include both formal and informal structures, and in an effort toward inclusion, a definition for an OHN was not provided in this study. For purposes of this study, the sense of connection to an OHN by the survey respondent was of greatest importance, which we believed should not have been constrained by a definition.

The COVID-19 response was defined as response and/or research related to the pandemic. For categorizing the respondents by geographic regions, the WHO list of member countries and regions was applied (www.who.int/countries). For several questions, such as those concerning the type of organization and sector, the survey respondents were able

to select multiple options from the list of possible answers, including the opportunity to select "other." Those survey respondents who were involved in a response were asked to indicate the type of work, geographic level of response, and skills and areas of expertise applied.

Statistical Analyses

We describe the data according to the background variables captured by the questionnaire. Since not all respondents answered all questions, we report the total number of respondents (N) who answered each question.

The main results are simple distributions, presented as counts and percentages. Differences between relevant proportions were evaluated using the Chi-square test, and considered statistically significant if the 2-sided p-value was $p < 0.05$. The sample size we aimed for was targeted for general descriptive statistics, and subgroup analyses were not a main objective.

We report odds ratio (OR) from a logistic regression model where the outcome was the reported involvement in COVID-19 response (yes/no), and dichotomous: "being part of an OHN" (yes/no) was the explanatory variable. We additionally evaluated the association with the sectors represented by at least 400 responses to the question (dichotomous variable: selected/not selected). Confounding was explored by observing any substantial change in OR after adding each of the variables, and interaction was tested for by offering an interaction term to the model. The predictive power of the logistic regression models is presented as the area under the receiver operating characteristic (ROC) curve.

Statistical tests were performed using GraphPad Prism version 6.0.1 for Windows (GraphPad Software, San Diego, California, USA; www.graphpad.com) and Stata 13.1 (StataCorp, College Station, TX, USA).

Ethics Approval

The research was exempted from ERC review by the Ad-Hoc Covid-19 Research Ethics Review Committee (WHO ERC/Covid-19). A link to a Participant Information Sheet (PIS) was included in the survey instructions (**Supplementary Material 3**).

Participation was completely voluntary, no questions were mandatory to answer, and the respondents consented for their answers being used by submitting them. The data were anonymous; the dataset was checked for completeness of anonymity and de-identified (**Supplementary Material 4**). No potentially identifiable human data are presented in this study.

RESULTS

Subject Population

The sample for this observational study included 1,050 respondents who were categorized by three relevant work variables—location (WHO region), type of organization, and work sector (**Figure 1**). The respondents were from 94 countries in all six WHO regions (**Figure 1A**). A large proportion of survey respondents who answered the question were from the Region of the Americas (572/1,037, 55.2%); 44.6% (462/1,037) were from the United States. Academic organizations (**Figure 1B**) were the most commonly selected affiliation (447/1,047, 42.7%), followed by governmental organizations at the national (176/1,047, 16.8%) and sub-national (165/1,047, 15.8%) levels.

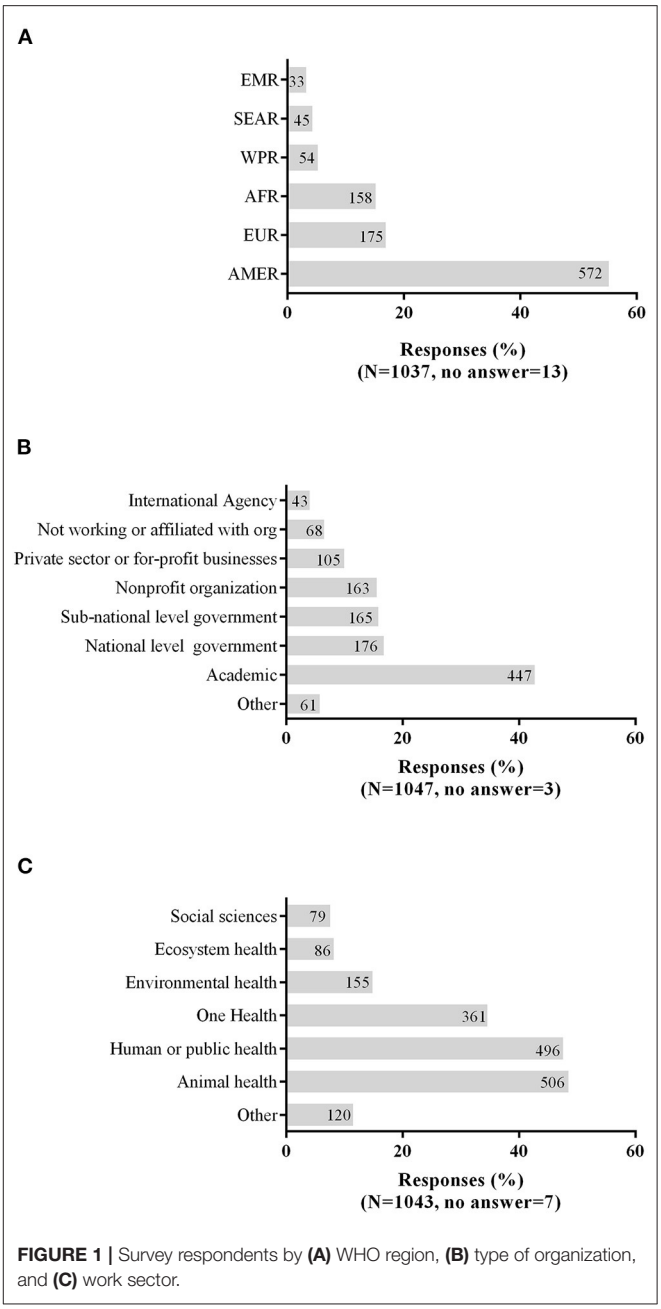

FIGURE 1 | Survey respondents by **(A)** WHO region, **(B)** type of organization, and **(C)** work sector.

The survey respondents were from a variety of work sectors (**Figure 1C**). A similar percentage reported working in animal health (506/1,043, 48.5%) and in human health or public health (496/1,043, 47.6%). The environmental health sector was selected by 14.9% (155/1,043) of respondents. Over one-third of respondents (361/1,043, 34.6%) self-identified as working in the One Health sector.

Overall, 13.2% (138/1,047) of the survey respondents indicated that they were working for or were affiliated with more

than one type of organization (**Supplementary Table 1**). One Health sector respondents were more likely to report working for more than two types of organization (p-value: <0.001); a total of 20.8% (75/361) of those self-identifying as working in the One Health sector reported working for more than one type of organization, compared to 9.2% (63/686) among those working in all other sectors combined.

The majority (299/361, 82.8%) of respondents who reported working in One Health sector also selected at least one other sector; 50.7% (183/361) selected at least two additional sectors. This is a higher proportion compared to 18.0% (123/682) who reported working in more than one sector and 4.4% (30/682) who reported working in more than two sectors among those who did not identify as working in the One Health sector ($p < 0.001$; **Supplementary Table 1**).

Participation in One Health Networks (OHNs)

Overall, 75.7% (788/1,041) of survey respondents identified as being part of an OHN. The number and percent of survey respondents, categorized by being self-described as part of an OHN, are presented by WHO region, type of organization, and work sector in **Table 1**. Across all WHO regions, all types of organizations, and all work sectors, the proportion of the sample reporting they were part of any OHN was always above 65.8%. The top three OHN activities that most survey respondents indicated they had ever participated in were, "received communication from an OHN," "social media communications," and "OHN- hosted webinars" (**Table 2**). **Supplementary Table 2** provides a summary of the characteristics of those respondents who indicated being part of an OHN compared to those who did not.

Involvement in COVID-19 Response

A total of 63.8% (661/1,036) of survey respondents indicated that they had been involved in COVID-19 response activities. **Table 3** summarizes the answers from survey respondents who were involved in the COVID-19 response regarding the type of work, geographic level of response, and skills and areas of expertise applied. The largest percentage of the respondents (309/681, 45.4%) indicated they were involved in education, including teaching and training. Over half the respondents indicated that their response activities were at the subnational level (364/651, 55.9%). The skills and areas of expertise applied included animal

TABLE 1 | Survey responses for being part of an OHN, involved in COVID-19 response, and both part of OHN and involved in COVID-19 response, by WHO region, type of organization, and work sector.

	Part of OHN		Involved in COVID-19 response		Part of OHN and involved in COVID-19 response	
	n	%	*n*	%	*n*	%
Where are you currently located? (WHO Region)						
Americas (572)	395	69.1	349	61.1	258	45.1
Europe (175)	127	72.6	111	63.4	81	46.2
Africa (158)	142	89.9	110	69.6	104	65.8
Western Pacific (54)	45	83.3	30	55.6	28	51.8
South-East Asia (36)	40	88.9	30	66.7	27	60.0
Eastern Mediterranean (33)	29	87.9	23	69.7	21	63.6
What type of organization do you currently work for or are you affiliated with?*						
Academic (447)	349	78.1	282	63.1	226	50.5
National level government (176)	139	79.0	124	70.5	108	61.3
Sub-national level government (165)	123	74.5	124	75.2	94	56.9
Non-profit organization (163)	131	80.4	109	66.9	96	58.8
Private sector or for-profit businesses (105)	74	70.5	69	65.7	36	34.2
Individual not working or affiliated with organization (68)	53	77.9	35	51.5	28	41.1
International Agency (37)	37	86.0	35	81.4	29	67.4
Other (61)	42	68.9	36	59.0	29	47.5
In what sector do you currently work?*						
Animal health (506)	402	79.4	279	55.1	227	44.8
Human or public health (496)	383	77.2	381	76.8	302	60.8
One Health (361)	318	88.1	257	71.2	228	63.1
Environmental health (155)	122	78.7	107	69.0	90	58.0
Ecosystem health (86)	76	88.4	59	68.6	55	63.9
Social sciences (79)	60	75.9	60	75.9	50	63.2
Other (120)	79	65.8	69	57.5	0.0	0.0

N, number of people that answered the question; n, number of responses *Possible to select multiple options, including "other," from a list. Sum of group percentages does not = 100%.*

TABLE 2 | Participation in OHN activities.

	n	%
Please indicate if you have ever participated in these OHN activities.* (*N* = 892, no answer = 158)		
Received communications from OHN list	474	53.1
Followed OHN on social media	379	42.5
Attended OHN hosted webinar	369	41.4
Attended online OHN conference/meeting	332	37.2
Attended in-person OHN conference/meeting	297	33.3
Invited other professionals to OHN activities	251	28.1
Used OHN to disseminate information	200	22.4
Participated in OHN workgroup/taskforce/committee	190	21.3
Participated in integrated OHN project	184	20.6
Organized OHN activity	180	20.2
Co-authored OH publication with OHN colleague	143	16.0
Participated in OHN offered training	141	15.8
Presented on OH topic for OHN	129	14.5

N, number of people that answered the question; n, number of responses *Possible to select multiple options, including "other," from a list. Sum of group percentages does not = 100%.*

TABLE 3 | COVID-19 response actions by type of work and by geographic level of response, and COVID-19 response actions by skills and areas of expertise applied.

	n	%
What is your type of work for the COVID-19 response?*		
(*N* = 681, no answer = 82, did not participate in COVID-19 response = 287)		
Education (teaching, presentation, training)	309	45.4
Practice (clinical, public health, lab support, data analysis)	264	38.8
Writing (blog, commentary, article, other publication)	187	27.5
Health policy and consultation	173	25.4
Research (basic, clinical, operational)	138	20.3
Administration and support	130	19.1
Research (social science, fieldwork)	127	18.6
Research (COVID-19 diagnostics, treatments, or vaccines)	90	13.2
Other	98	14.4
At what level is your COVID-19 response and/or research activities?*		
(*N* = 651, no answer = 89, did not participate in COVID-19 response =310)		
Subnational—local, district, state	364	55.9
National—in one country	301	46.2
International—in multiple countries	144	22.1
Other	0.0	0.0
What skills/areas of expertise have you applied to the COVID-19 response?*		
(*N* = 698, no answer = 81, did not participate in COVID-19 response = 271)		
Animal health	328	47.0
Disease surveillance	255	36.5
Information/knowledge management	226	32.4
Communications and media	220	31.5
Community engagement	180	25.8
Risk assessment and management	172	24.6
Risk communications	162	23.2
Infection and Prevention Control (IPC)	160	22.9
Outbreak or epidemiological research	150	21.5
Data management	136	19.5
Environmental health	123	17.6
Basic research on coronavirus	114	16.3
Laboratory support and diagnostics	112	16
Contact tracing	111	15.9
Social sciences	88	12.6
Logistics/supply chain	68	9.7
Case management	64	9.2
Testing and diagnostics development	56	8.0
Human clinical care	52	7.4
Operational research	51	7.3
Clinical research	50	7.2
Vaccine development	19	2.7
Other	59	8.5

N, number of people that answered the question; n, number of responses. *Possible to select multiple options, including "other," from a list. Sum of group percentages does not = 100%.*

health (328/698, 47.0%), disease surveillance (255/698, 36.5%), and information/knowledge management (226/698, 32.4%).

Among the survey respondents indicating they were involved in the COVID-19 response, 79.9% (528/661) reported being part of an OHN. Among respondents indicating they were part of an OHN, 67.2% (528/786) were involved in COVID-19 response activities. The proportion involved in the pandemic response was smaller at 53.2% (133/250) among those who did not identify as being part of an OHN. Being part of an OHN was positively and significantly associated with involvement in the pandemic response with a univariable odds ratio of 1.8 (95% confidence interval: 1.348–2.405); the area under the ROC curve was 0.555 (**Table 4**).

Two univariable logistic regression models investigating the association between being from the two most commonly selected sectors and being involved in COVID-19 response activities showed that being from the animal health sector was negatively associated with involvement in the pandemic response, and being from the human health or public health sector was positively associated with involvement in the pandemic response (odds ratio 0.5, 95% confidence interval: 0.382–0.639, and odds ratio 3.1, 95% confidence interval: 2.393–4.091, respectively). Further, two separate models including each of these two sectors as an explanatory variable alongside being part of an OHN as the main focus explanatory variable, supported the results of the univariable analyses, and there were no substantial changes in odds ratios. The first model showed that being from the animal health sector was negatively associated (odds ratio 0.5, 95% confidence interval: 0.353–0.597) while being part of an OHN was positively associated (odds ratio 2.0, 95% confidence interval: 1.481–2.688) with being involved in COVID-19 response; area under the ROC curve was 0.619. The second model showed that being from the human health or public health sector was positively associated (odds ratio 3.1, 95% confidence interval: 2.381–4.094) and being part of an OHN was positively associated (odds ratio 1.8, 95% confidence interval: 1.318–2.406) with being

TABLE 4 | Contingency table showing the association (odds ratio: 1.8, 95% confidence interval: 1.3–2.4, Chi-square: 16.04) between being part of an OHN and being involved in the COVID-19 response.

	Involved in COVID-19 response	Not involved in COVID-19 response	No answer for COVID-19 response	Totals
Part of OHN	528	258	2	788
Not part of OHN	133	117	3	253
No answer for OHN	2	3	4	9
Totals	663	378	9	1,050

involved in COVID-19 response; area under the ROC curve was 0.663. No interaction was evident between either of the sets of two explanatory variables. The sample size did not allow a similar analysis of the environmental sector.

Barriers and Facilitators to Involvement in COVID-19 Response

Overall, 38.3% (387/1,011) of survey respondents reported no perceived barriers to their participation in COVID-19 response activities. The most frequently reported barrier was "no financial support" (248/1,011, 24.5%), followed by "lack of opportunity or path for involvement" (211/1,011, 20.9%). Personal and organizational interest were the greatest facilitators for involvement (**Table 5**).

Figure 2 presents the perceived barriers to involvement in the COVID-19 response for the WHO regions that were represented by at least 100 responses to the question, notably the European, African, and Americas regions. Barriers perceived by survey respondents from the European and Americas regions were generally similar to one another. The most frequently reported barrier by respondents from the African region was "lack of financial support" (66/158, 41.8%). The proportion selecting this as a barrier was significantly lower in the other two regions: 19.4% (34/175) in the European region and 17.8% (102/572) in the Americas ($p < 0.001$). A significantly lower percentage of respondents from the African region indicated not knowing how to get involved (13/158, 8.2%), compared to respondents from the Americas (84/572, 14.7%; $p < 0.05$).

Perceived Usefulness of OHNs During COVID-19 Response

While 43.6% (235/539) of the survey respondents who affiliated with an OHN that contributed to the COVID-19 response found OHNs very helpful or extremely helpful, 19.1% (103/539) found OHNs to be of little or no help (**Supplementary Figure 1**). The OHN offerings most frequently reported as especially useful were "increasing public awareness of the value of One Health" (712/923, 77.1%) and "networking with professionals across sectors with common interests" (517/923, 56.0%; **Table 6**).

DISCUSSION

One Health has been invoked on the international stage as a major principle with which to fight the COVID-19 pandemic and to prevent future pandemics. This study describes the contributions of a cross section of the global One Health community that included a broad representation that spanned geographic regions, organizations, and work sectors in the early stages of the COVID-19 pandemic. It captures what individuals regarded as barriers and facilitators to their involvement, including the role of participating in an OHN, and reveals where further research is warranted.

Being part of an OHN was positively associated with involvement in COVID-19 responses. This provides evidence for the value of OHNs for workforce capacity building. However, not all respondents found OHNs helpful. For those survey participants who were part of an OHN, this could be interpreted as indication of a need for OHNs to better align their activities with workforce priorities and to consider and measure perceived value for those activities. Our finding that those who were part of an OHN were almost two times more likely to be involved in the COVID-19 response may indicate greater awareness and access to opportunities through an OHN connection. Further research is needed to fully explore critical areas for intervention and how OHNs can be a vehicle to support a global outbreak response workforce.

TABLE 5 | Barriers and facilitators to participation in COVID-19 response activities.

	n	%
Barriers to participation in COVID-19 response* (*N* = 1,011, no answer = 39)		
There were no barriers to my participation	387	38.3
No financial support	248	24.5
No opportunity or path for involvement	211	20.9
Not part of my job	172	17.0
No time	149	14.7
Don't know how to get involved	143	14.1
Lack of organizational interest	94	9.3
Lack of personal interest	24	2.4
Other	123	12.2
Facilitators to participation in COVID-19 response* (*N* = 1,015, no answer= 35, did not participate in COVID-19 response = 295)		
Personal interest	508	50.1
Organizational interest	391	38.5
I have not participated in COVID-19 response and/or research	295	29.1
Part of established duties at my current job	295	29.1
Part of a new project/special deployment for COVID-19	223	22.0
Availability of new COVID-19 funding	124	12.2
I learned of volunteer opportunity through OHN	42	4.1
I learned of job opportunity through OHN	21	2.1
Other	59	5.8

*N, number of people that answered the question; n, number of responses. *Possible to select multiple options, including "other", from a list. Sum of group percentages does not = 100%.*

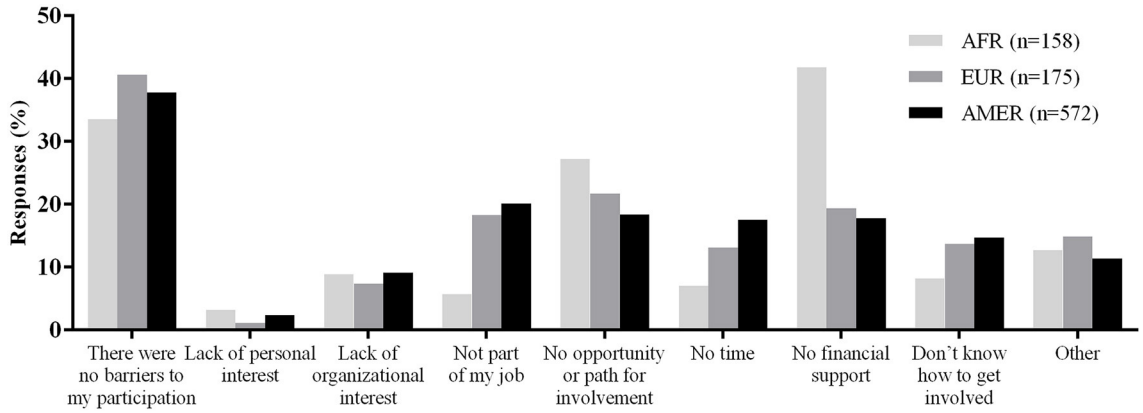

FIGURE 2 | Perceived barriers to participation in COVID-19 response by WHO region.

TABLE 6 | Perceived usefulness of OHN activities during the COVID-19 response.

	n	%
What OHN offerings do you think are especially useful during the COVID-19 response?*		
(*N* = 923, no answer = 127)		
Increased public awareness of the value of OH	712	77.1
Networking with professionals across sectors with common interests	517	56.0
Trusted information about the COVID-19 pandemic	466	50.5
Links to popular media items relevant to OH and current events	338	36.6
Targeted training opportunities	335	36.3
Information about professional, career, and service opportunities	310	33.6
Opportunities to contribute in ways that my employment does not provide	269	29.1
Other	33	3.6

*N, number of people that answered the question; n, number of responses. *Possible to select all that apply from list of options, including "other." Sum of percentages does not = 100%.*

In this study, many respondents were affiliated with academic organizations, which may reflect some of the criticism that the One Health concept remains an academic exercise with little practical operationalization (38, 39). However, a substantial proportion of the survey respondents were affiliated with governmental organizations, highlighting channels toward greater operationalization of One Health. These results can inform sampling designs that ensure greater responses from multiple stakeholder groups, including the public sector, development institutions, and non-governmental organizations (NGOs).

The similar proportion of respondents in our study from human or public health and animal health sectors indicated a balance in input from key professional arenas within the global One Health community. A smaller proportion of respondents identified as being from the environmental sector, the third classical pillar of One Health. This may be a shortcoming in the reach of the survey dissemination to those working in environmental and ecosystem health. Indeed, limited representation of the environmental sector is often noticed in One Health initiatives with calls for better engagement (25, 40). Additionally, with growing awareness of the importance of the social drivers of disease, a specific area for public health strengthening is the integration of social science perspectives into One Health (41, 42). Our study sample included a relatively small proportion of respondents from the social science sector. The results of this study can help in planning sampling for future studies and targeted approaches for reaching out to underrepresented fields.

The survey respondents who were involved with the COVID-19 response reported various types of work, geographic level of response, and skills and areas of expertise applied. Further studies are needed to investigate other aspects of worker pandemic response activities, such as the extent of involvement in terms of time used or proportion of working time allocated. Furthermore, knowing the impact of other multisectoral workforce involvement outside of OHNs would be useful to ascertain lessons learned from this pandemic.

The survey respondents reported a number of barriers that hindered involvement in COVID-19 response activities, although the reason for the barriers was beyond the scope of this study and merits further investigation. These results highlight opportunities for regional OHNs, as well as other actors, to find tailored solutions to enable involvement and activation of professional expertise. This might include enhanced dissemination of relevant opportunities, as exemplified by the joint GOARN call to action (28), paths for involvement for experts across the fields, and targeted funding programs for OHN support.

One barrier to involvement in COVID-19 response activities reported was lack of opportunities or paths for involvement, which can be addressed at the local, national, regional, and international levels. There is room for improvement in the extent to which One Health is taught and embraced in professional education across sectors with calls for the structured incorporation of One Health into professional degree programs

(24). OHNs are well-positioned to provide the targeted One Health professional development, continuing education, and workforce training needed. The USAID One Health Workforce Next Generation Project, for example, is specifically building the capacity of OHNs worldwide to prevent, detect, and respond to COVID-19 and other infectious diseases (43). A deeper analysis of the barriers and facilitators, matched with strategies to address them, could help to inform local, national, and global initiatives to guide workforce policy and management in light of what we have learned from COVID-19 (37, 44).

This study had some relevant limitations. A major one was bias due to the dissemination routes and snowball sampling method, which oversampled the One Health community and possibly also those involved in COVID-19 response activities. While the geographical distribution of the respondents reflected the global reach of OHN networks, it also revealed shortcomings in the recruiting of survey participants. These results, however, highlight where OHNs need to focus attention for inclusion by, for example, addressing language barriers or other obstacles to participation in the study and by better coordination across OHNs to expand reach and leverage resources.

Collider bias also could have affected our results and limited the ability to make comparisons between those who reported being part of an OHN and those who did not. Other limitations included an English-only questionnaire, self-reporting, and general constraints of questionnaire studies. For example, despite careful design and piloting, some concepts in the questions may have been understood differently by some respondents. Free text responses might have also provided different results for some of the questions beyond the options provided. Importantly, the concept of "OHN" was not defined in this work. Moreover, lack of sociodemographic data was a limitation. Future studies should include variables, such as age, ethnicity, gender, and career stage to evaluate the presence of selection and response bias, as well as any confounding variables. This would also provide insight into any disparities observed based on these sociodemographic variables as a first step to addressing them.

Operationalizing One Health will need to be adapted to build the workforce competencies required for the post-COVID-19 future. Despite the proven benefit of One Health approaches during pandemics (14), the establishment of an effective multisectoral workforce remains problematic. This is due, in part, to the lack of integration of the One Health approach into current international treaties (45). For example, shortcomings in including the One Health approach in the International Health Regulations (IHR) have been linked to delayed and suboptimal action during the early response to COVID-19 (36, 45). Calls for global governance and financing mechanisms to advance One Health as a guiding principle to reform global public health are key to actionable system-level solutions to scale up pandemic preparedness, including workforce development (46). Greater understanding of the activities and needs of the One Health workforce during a pandemic response helps to pave the way for meaningful integration into coordinated and shared strategies for preventing, detecting, and responding to global public health emergencies.

DATA AVAILABILITY STATEMENT

The coded dataset of de-identified survey responses used in this study is included as **Supplementary Material**. Further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The research was exempted from ERC review by the Ad-Hoc Covid-19 Research Ethics Review Committee (WHO ERC/Covid-19). Participation was completely voluntary, no questions were mandatory to answer, and the respondents consented for their answers being used by submitting them. The data were anonymous; the dataset was checked for completeness of anonymity and de-identified. No potentially identifiable human data are presented in this study.

AUTHOR CONTRIBUTIONS

LSt, VD, and CS conceptualized the study. LSt and CS verified the underlying data and had access to all data. LSe ran the statistical analyses and created the figures. PJ, JB, LSt, and VD contributed to the data analysis. LSt prepared the first manuscript draft. All authors participated in the design of the study, had access to the de-identified dataset, participated in interpretation of the results, contributed to writing and editing the paper, and approved the final manuscript for publication.

FUNDING

This work was supported by the One Health Commission and the European Union Horizon 2020 Research and Innovation Program under grant agreement number 773830: One Health European Joint Programme. The European Union Horizon 2020 Research and Innovation Program provided funds for the open access publication fee. The funders had no role in the study design, data collection, data analysis, data interpretation, or writing the manuscript.

ACKNOWLEDGMENTS

We thank all the survey respondents and everyone who helped to distribute the survey link. Dr. John Lamb provided helpful comments on the manuscript. PJ and LSe are part of the One Health European Joint Programme consortium. Selected preliminary results of this study have been presented at the 8th International Meeting on Emerging Diseases and Surveillance, IMED 2021, and at the Annual Scientific Meeting of the One Health European Joint Programme, OHEJP ASM 2021.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.830893/full#supplementary-material

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frontiers in Public Health

ORIGINAL RESEARCH
published: 17 March 2022
doi: 10.3389/fpubh.2022.776850

Does Environmental Information Disclosure Improve the Health Level of Middle-Aged and Old Residents? Evidence From China

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Objective: The purpose of this study is to empirically examine the impact of environmental information disclosure on the health of middle-aged and old residents and investigate whether such disclosure can improve the health of middle-aged and old residents.

Methods: This study matches the data of the Pollution Information Transparency Index (PITI) and China Health and Retirement Longitudinal Study in 2018 and uses the ordered logistic regression model to assess the impact of environmental information disclosure on the health of middle-aged and old residents. Furthermore, stepwise regression, ordinary least square, and ordered probit regression models are used for robustness tests. The IV-Ordered probit regression model solves the endogenous problem.

Results: Environmental information disclosure has a significant positive correlation with the health level of middle-aged and old residents. After the robustness test and endogenous problem handling, this conclusion still holds. Estimation results show that when PITI increases by 1 unit, the probability of improving the self-reported health level and actual health level of middle-aged and old residents increases by 1 and 0.87%, respectively. The impact of environmental information disclosure on the health of middle-aged and old residents also has significant regional heterogeneity. Specifically, the impact is mainly reflected in the central region of China.

Conclusion: Environmental information disclosure can improve the health of middle-aged and old residents. To improve the health of middle-aged and old residents, it is necessary to implement and enhance the environmental information disclosure system continuously. The anti-driving effect of environmental information disclosure on the treatment of environmental pollution must be intensified further, particularly focusing on the central region of China, where is more polluted and more concentrated than other regions.

Keywords: environmental information disclosure, health level, middle-aged and old residents, impact analysis, empirical research

OPEN ACCESS

Edited by:
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Reviewed by:
Jing Han,
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Zhihua Xu,
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Specialty section:
This article was submitted to Environmental health and Exposome, a section of the journal Frontiers in Public Health

Received: *14 September 2021*
Accepted: *21 February 2022*
Published: *17 March 2022*

Citation:
Yu X, Shen W and Lin S (2022) Does Environmental Information Disclosure Improve the Health Level of Middle-Aged and Old Residents? Evidence From China. Front. Public Health 10:776850. doi: 10.3389/fpubh.2022.776850

INTRODUCTION

Population aging is an important issue currently facing China (1–3). According to the results of China's seventh national census (4), as of November 2020, China has a population of 264,018,766 people aged 60 and over, accounting for 18.7% of the total population and far exceeding the 10% specified in internationally accepted aging standards. There are 190,635,280 people aged 65 and over, accounting for 13.50% of the total population and far more than the 7% stipulated in international standards. Furthermore, China's aging population is increasing. Compared with the sixth national census in 2010, the proportion of people aged 15–59 in the seventh national census in 2020 dropped by 6.79%, but the proportion of the population aged 60 and 65 years and above increased by 5.44 and 4.63%, respectively (5). In addition to the ever-increasing total number of middle-aged and old people, China's middle-aged and old residents are also plagued by chronic diseases (6, 7). According to official Chinese statistics (8), in 2018, the prevalence of chronic diseases among residents over 45 years old in China was 47.32%, while the prevalence of chronic diseases among residents aged 65 and over was as high as 62.33%. The high proportion of the middle-aged and old population and the high prevalence of chronic diseases, coupled with China's low-level doctor-patient ratio (9), have further aggravated medical pressure in the country and hindered its social and economic development (10, 11).

Numerous studies have confirmed the close relationship between the ecological environment and the health of residents (12–14), especially in terms of middle-aged and old residents (15–17). China's rapid economic development has significantly improved the living standards of such residents. However, China's economic growth has been characterized by high energy consumption, high pollution, and high emissions (18) since the reform and opening-up, which has brought various ecological and environmental issues such as smog pollution, which is well-known to the public (19), industrial pollution (20), water pollution (21), and offshore pollution (22). These environmental pollution problems have caused great harm to the health of residents. Kampa and Castanas (23) believes that air pollution has both acute and chronic effects on human health, affecting a significant number of different systems and organs, including heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults. Mannucci and Franchini (24) indicates that at least seven million deaths globally are attributable to the effects of air pollution annually. Ashbolt (25) and Schwarzenbach et al. (26) believe that drinking water is a major source of microbial pathogens in developing regions. Wang and Yang (27) studies the relationship between health and water pollution using the random-effects and random effects logit models. He demonstrates that the negative health effects of water pollution remain a major source of morbidity and mortality in China.

To control environmental pollution, the Chinese government has issued a large number of policies, including environmental information disclosure. Environmental information disclosure is an environmental governance policy based on information disclosure, which is regarded as a supplement to administrative and market means (28–30). Since the "*Environmental Protection Law of the People's Republic of China*" put forward the concept of environmental information disclosure in 1989, such disclosure in China has experienced more than 30 years of practice and development, and the related policy has been gradually improved through continuous adjustments and changes (31). If we advance the time to before the reform and opening up, China's environmental information disclosure system has even gone through about 70 years of construction and exploration, forming a circular circle from system formulation, implementation to amendment. Before the reform and opening up, environmental information in China was an implicit disclosure. After the 1990s, China's environmental information entered a formal disclosure phase. After entering the 21st century, environmental information began to be disclosed centrally and a series of supporting policies began to be released, including the "*Measures for Disclosure of Environmental Information*," "*Application for Disclosure of Environmental Information According to Law*," "*Measures for Reporting Environmental Emergency Information*," and "*Measures for Disclosure of Environmental Information by Enterprises and Institutions*." As a policy tool, environmental information disclosure has had a significant positive impact on improving China's ecological environment (32–35).

At present, scholars have studied the relationship between environmental pollution and the health of middle-aged and old residents as well as the relationship between environmental information disclosure and environmental pollution. However, they rarely combine the two to study the impact of environmental information disclosure on the health of middle-aged and old residents. In terms of macro policy, the Chinese government has also placed greater emphasis on environmental and health issues. In the 14th Five-Year Plan released in March 2021, it is proposed to comprehensively promote the construction of "Healthy China," and set a goal to increase life expectancy per capita by 1 year during the 14th Five-Year Plan. At the 75th session of the United Nations General Assembly, Chinese President Xi Jinping directly announced China's "dual carbon" goal, which is to peak CO_2 emissions by 2030 and work toward achieving carbon neutrality by 2060. In conclusion, it is of great theoretical and practical significance to study the relationship between environmental information disclosure and the health level of middle-aged and old residents.

This study matches the environmental information disclosure indicators at the urban level in China with the micro-survey data of middle-aged and old residents. It uses the ordered logistic regression model to study the impact of environmental information disclosure on the health of middle-aged and old residents. We find that environmental information disclosure can improve the health level of middle-aged and old residents. After the robustness test and endogenous problem handling, this conclusion still holds. We also find significant regional differences in the impact of environmental information disclosure on the health of middle-aged and old residents, and this impact is mainly reflected in the central region of China. The marginal contribution of this study is that we provide a new perspective for studying the impact of environmental policies on health, that is, environmental information disclosure

system. From the perspective of environment and health, the implementation of the environmental information disclosure system is not only conducive to solving the problem of environmental pollution, but also has a positive impact on the improvement of residents' health. These results provide more evidence to government to development and implement evidence-based strategies and policies to improve the residents' health.

The remainder of this study is organized as follows. Section Materials and Methods introduces the materials and methods, including data sources, specification of variables and ordered logistic regression model. Section Results presents the results of the research, which used Stata, including tests of parallel regression assumption, benchmark regression, robustness test, endogenous problem handling, and regional differences. Section Discussion discusses the empirical results based on previous studies. Finally, Section Conclusion provides a summary of the results and puts forward some policy recommendations and the direction of further research.

MATERIALS AND METHODS

Data Sources

The data source of this article includes two parts, with the most important one being the China Health and Retirement Longitudinal Study in 2018 (CHARLS-2018) hosted by the National School of Development of Beijing University. CHARLS is a longitudinal survey that aims to be representative of the residents in mainland China aged 45 and older, with no upper age limit. It attempts to set up a high-quality public micro-database that can provide a wide range of information from socioeconomic status to health conditions to serve scientific research needs or the elderly (36). Currently, CHARLS is widely used in the study of the health of middle-aged and old people in China (37–40). The national baseline survey was conducted in 2011, with wave 2 in 2013, wave 3 in 2015, and wave 4 in 2018, respectively. To ensure sample representativeness, the CHARLS baseline survey covered 28 provinces, 150 countries/districts, and 450 villages/urban communities across the country, reflecting the middle-aged and older Chinese population collectively. The sample of CHARLS-2018 involved ∼19,000 individuals in 12,400 households. Data of CHARLS-2018 are available at http://charls.pku.edu.cn/.

Another source of data is the Pollution Information Transparency Index (PITI), which is co-developed by the Institute of Public and Environmental Affair (IPE) and The Natural Resources Defense Council. At present, many studies use PITI to represent the environmental information disclosure of the region (41–43). Matching with CHARLS-2018, this article selects the PITI of 2018, covering 29 provinces and 120 cities in China. Data and more information about PITI are available at http://www.ipe.org.cn/.

Specification of Variables

Explained Variables

The explained variable of this article is the health level of middle-aged and old residents, which is divided into self-reported health level (*self_HL*) and actual health level (*actual_HL*). Self-reported health level is an individual's subjective judgment of their health. Using it to characterize health status can meet the needs of analyzing the relationship between environment and health to a large extent (44). Self-reported health level can be obtained through a question in the CHARLS-2018 questionnaire:

- What do you think of your health?

In the questionnaire, the answer to this question is divided into five levels: 1 = very good, 2 = good, 3 = fair, 4 = poor, and 5 = very poor. To be consistent with the direction of the explanatory variables (the larger the value, the better), we re-encoded the level of this question to 1 = very poor, 2 = poor, 3 = fair, 4 = good, and 5 = very good.

The actual health level needs to be determined through a series of tests. This article selects a series of physical functional limitations in the questionnaire to be investigated. These questions include:

- Do you have any difficulty with running or jogging about 1 km?
- Do you have difficulty with getting up from a chair after sitting for a long period?
- Do you have difficulty with climbing several flights of stairs without resting?
- Do you have difficulty with stooping, kneeling, or crouching?
- Do you have difficulty with reaching or extending your arms above shoulder level?
- Do you have difficulty with lifting or carrying weights over 5 kg, such as a heavy bag of groceries?
- Do you have difficulty with picking up a small coin from a table?

In the questionnaire, these seven questions adopt a four-level evaluation standard: 1 = No, I don't have any difficulty, 2 = I have difficulty but can still do it, 3 = Yes, I have difficulty and need help, and 4 = I can't do it. We add up the total scores of these seven questions and measure the actual health level of residents according to **Table 1**. The higher the total score, the lower the actual health level. As with the self-rated health level, we also coded these levels as follows: 1 = very poor, 2 = poor, 3 = fair, and 4 = good.

Explanatory Variables

The explanatory variable of this article is the level of environmental information disclosure, measured by PITI. The full score of PITI is 100. The higher the score, the higher the level of environmental information disclosure in the region. PITI's accounting is divided into five dimensions: regulatory information, self-monitoring, interactive response, emissions data, and environmental impact assessment (EIA) information, including eight indicators. **Table 2** shows the specific description and weight of each indicator.

Control Variables

To improve the accuracy of the model estimation results, we refer to some literature that studies the factors affecting the health of middle-aged and old residents. Based on the availability of

data, we selected some factors as control variables and put them in the model. There are five dimensions of control variables: (1) Demographic characteristics, including gender (*gender*), age (*age*), education level (*edu*), and marriage status (*marriage*); (2) Living habits, including sleep status (*sleep*), whether the individual smokes (*smoke*), frequency of drinking (*drinking*), and whether physical activity is performed (*physic*); (3) Medical behaviors, including whether to participate in medical insurance (*insurance*) and medical and fitness expenditures (*health_ep*); (4) Health level in childhood (*health_ch*), that is, the health status before the age of 15; and (5) Urban or rural residents (*urban*). It is worth noting that unhealthy diet is also an important risk factor affecting the health level of middle-aged and old residents. However, there was no survey related to dietary habits in the CHARLS-2018 questionnaire; therefore, the control variables in the model do not include this factor. **Table 3** shows the specific description and value meaning of all variables.

Table 4 shows the descriptive statistical results of all variables. The second column indicates the number of observations (Obs) for each variable. PITI matches approximately half of the CHARLS-2018 sample. The mean, standard deviation (SD), minimum (Min), and maximum (Max) can reflect the measures of dispersion of the sample. To test whether multicollinearity exists between variables, we calculate the variance inflation factor (VIF) of the explanatory variable and all control variables. According to commonly used judgment standards (19, 45), these VIFs are significantly <10, thereby indicating that the variables selected in this article do not have multicollinearity.

TABLE 1 | Evaluation standard of *actual_HL*.

Score	Score = 7	7 < score ≤ 14	14 < score ≤ 21	21 < score ≤ 28
actual_HL	Good	Fair	Poor	Very poor

TABLE 2 | Accounting standards of PITI.

Dimensions	Indicators	Weights (%)
Regulatory information	Daily violation records that exceed the standard	25
	Evaluation of corporate environmental behavior	5
Self-monitoring	Automatic monitoring of state-controlled enterprises	20
	Key polluting enterprises	6
Interactive response	Environmental protection inspectors and complaints	7
	Disclosure based on application	8
Emissions data	Disclosure of corporate emissions data	14
EIA Information	Disclosure of EIA Information	15

Source of information: The 2018-2019 Annual Pollution Information Transparency Index Assessment.

Ordered Logistic Regression Model

The explained variable in this paper is an ordinal variable, so it is not accurate enough to estimate with the traditional ordinary least square (OLS) regression model (46–48). The ordered logistic

TABLE 3 | Variable definitions.

Types	Dimensions	Symbol	Remarks
Explained variables	Health level of middle-aged and old residents	*self_HL*	1 = Very Poor, 2 = Poor, 3 = Fair, 4 = Good, 5 = Very good
		actual_HL	1 = Very Poor, 2 = Poor, 3 = Fair, 4 = Good
Explanatory variables	Degree of environmental information disclosure	*PITI*	–
Control variables	Demographic characteristics	*gender*	1 = Male, 2 = Famale
		age	–
		edu	Value range 1–11[a]
		marriage	1 = Married, 0 = Never married/Separated/Divorced/Widowed
	Living habits	*sleep*	During last month average hours of actual sleep
		smoke	1 = Yes, 0 = No
		drinking	1 = Drink more than once a month, 2 = Drink but less than once a month, 3 = Don't drink
		physic	1 = Yes, 0 = No
	Medical behavior	*insurance*	1 = Yes, 0 = No
		health_ep	Unit: 1,000 Yuan
	Health level in childhood[b]	*health_ch*	1 = Poor, 2 = Fair, 3 = Good, 4 = Very good, 5 = Excellent
	Urban or rural residents	*urban*	1 = Urban, 0 = Rural

[a] *1 = No formal education, 2 = Did not finish primary school, 3 = Sishu/home school, 4 = Elementary school, 5 = Middle school, 6 = High school, 7 = Vocational school, 8 = 2-/3-Year College/Associate degree, 9 = 4-Year College/Bachelor's degree, 10 = Master's degree, 11 = Doctoral degree/Ph.D.*
[b] *Childhood means before the age of 15.*

TABLE 4 | Descriptive statistics and multicollinearity test.

Variable	Obs	Mean	SD	Min	Max	VIF
self_HL	18,069	3.049	1.025	1	5	–
actual_HL	19,259	3.076	0.763	1	4	–
PITI	8,658	58.89	12.41	21.65	82.40	1.02
gender	19,584	1.525	0.499	1	2	2.76
Age	19,262	62.00	10.12	45	118	1.22
Edu	19,584	3.448	1.938	1	11	1.28
marriage	19,597	0.849	0.358	0	1	1.12
sleep	19,661	6.302	2.135	0.5	15	1.03
smoke	19,597	0.427	0.495	0	1	2.43
drinking	19,501	2.400	0.874	1	3	1.35
physic	19,597	0.896	0.306	0	1	1.03
insurance	19,597	0.967	0.178	0	1	1.01
health_ep	18,933	6.986	24.77	0	1,200	1.01
health_ch	18,099	3.333	1.109	1	5	1.03
urban	19,597	0.403	0.491	0	1	1.11

TABLE 5 | Parallel regression assumption test results.

Test methods	*self_HL*		*actual_HL*	
	Chi2	*P* > Chi2	Chi2	*P* > Chi2
Brant test	3.645	0.302	1.600	0.449
LR test	3.509	0.320	1.658	0.437
Wald test	3.493	0.322	1.659	0.436
Score test	3.494	0.322	1.659	0.436
Wolfe-Gould test	3.591	0.309	1.737	0.420

H0: Parallel Regression Assumption holds.

(Ologit) regression model is more suitable for dealing with such problems (49). It estimates the effects of a set of independent variables (numerical or categorical) on the logarithm of the probability that the dependent variable assumes low values rather than high values (50). The benchmark model constructed in this article is as follows:

$$HL_i = \beta_1 PITI_i + \beta_2 Control_i + \varepsilon_i$$

where HL_i is the health level of i, $PITI_i$ is the PITI of the city where i is located, $Control_i$ refers to all control variables, and ε_i is the random error term. Assuming that ε_i follows the logistic distribution, and the ordered explained variable has j distinct values, the relationship with theX_k explanatory variables for j varying between 1 and J-1 can be expressed through the following formula:

$$\log\left[\frac{\mathbf{p}\left(Y \leq \mathbf{j} \middle| X\right)}{\mathbf{p}\left(Y > \mathbf{j} \middle| X\right)}\right] = \alpha_{\mathbf{j}} - \sum_{\mathbf{k=1}}^{\mathbf{K}} \beta_{\mathbf{k}} X_{\mathbf{k}} = \alpha + X\beta$$

where α_j is the intercept and indicates the probability that the explained variable assumes low values rather than high values in case of nullity of all the explanatory variables. β_k represents the log (*ODDS*) change corresponding to a unitary increase of the X_k variables. Positive values of the β_k coefficients correspond to higher probabilities that the explained variable assumes high values, and vice versa (51).

RESULTS

Tests of Parallel Regression Assumption

Ologit regression model is performed under the assumption of cumulative logit parallelity (52). Therefore, we need to test the parallel regression assumption of the model first, that is, to test whether the influence of each value level of the explanatory variable on the explained variable is the same in each regression equation. **Table 5** shows the results of five test methods. The data in the table indicates that whether *self_HL* or *actual_HL* is used as the explained variable, and the *P*-value of the parallel hypothesis test obtained by all methods is >0.1, indicating that all the probabilities show none significance. In particular, the parallel regression assumption holds, and we can use the Ologit regression model for research.

Benchmark Regression

Table 6 shows the benchmark regression results of the model. Since the information reflected by the coefficients in the Ologit regression model is limited, we further calculate the odds ratio [$odds\ ratio = \exp\left(coefficient\right)$] of each variable to make it easier to understand the regression results.

From the results in **Table 6**, we can conclude the following:

(1) Whether *self_HL* or *actual_HL* as the explained variable, the estimated coefficients of *PITI* are significantly positive, thereby indicating that environmental information disclosure has a significant positive correlation with the health level of middle-aged and old residents. When *self_HL* is used as the explained variable, the odds ratios of *PITI* is 1.0100, and when *actual_HL* is used as the explained variable, the odds ratios of *PITI* is 1.0087. These results indicate that when environmental information disclosure level increases by 1 unit, the probability of improving the self-reported health level and actual health level of middle-aged and old residents increases by 1 and 0.87%, respectively.

(2) In terms of the influence of the control variables on the explained variables, we choose a model with a better fitting effect for interpretation, that is, taking *actual_HL* as the explained variable. On the basis of the regression results, we can divide these control variables into three categories. The first type is that the regression coefficient is significantly positive, including *edu*, *marriage*, *sleep*, *physic*, *health_ch* and *urban*. Combined with **Table 3**, the outcome reveals that middle-aged and old residents with higher education and adequate sleep have better health conditions. Physical activity also has a significant positive impact on the health of middle-aged and old residents. Compared with rural areas, urban middle-aged and old residents have a higher level of health. The second type of control variable is that the regression coefficient is significantly negative, including

gender, *age*, *smoke*, *drinking*, and *health_ep*. These results indicate that among middle-aged and old residents, the health of females is worse than that of males. In addition, the older the age, the higher the expenditure on medical and fitness, and the middle-aged and old residents who have smoking and drinking habits have worse health. The third type is the control variable with an insignificant regression coefficient, which is only *insurance*. The reason may be that this control variable in the sample does not have a significant binary classification. According to statistics, the medical insurance participation rate of Chinese residents in 2018 exceeded 95%.

Robustness Test

Stepwise Regression

The process of stepwise regression is to first regress the explanatory variable to the explained variable separately and then gradually add the control variables and observe whether the sign and significance of the coefficient of the explanatory variable have changed to judge the robustness of the result. **Tables 7**, **8**, respectively, show the stepwise regression results with *self_HL* and *actual_HL* as the explained variables. Among them, Column 1 presents the regression result without adding any control variables, and Columns 2–6 show the regression results after gradually adding the control variables. Owing to space limitations, we only list the coefficients, robust standard errors, and odds ratio of the explained variables in the text. The results in **Tables 7**, **8** show that whether *self_HL* or *actual_HL* is used as the explained variable, in all cases, the coefficient of the core explanatory variable *PITI* is significantly positive at the 1% statistical level, and the odds ratio is basically maintained at about 1%.

Change Estimation Method

Table 9 reports the estimated results using OLS and ordered probit regression models. We can find that after changing the estimation method, the regression coefficients of the core explanatory variable *PITI* to the explained variables *self_HL* and *actual_HL* are still significantly positive. This result confirms the robustness of the conclusions drawn in this article once more.

Endogenous Problem Handling

There may be a reciprocal causation relationship between environmental information disclosure and the health of middle-aged and old residents. On the one hand, environmental information disclosure has an impact on the health of middle-aged and old residents, which is the causal relationship that this article focuses on. On the other hand, the poor health of middle-aged and old residents may force companies and governments to strengthen environmental information disclosure to promote environmental improvement. In addition, although we have added a large number of control variables to the model to minimize the impact of missing variables on the model estimation results, due to the limitations of the survey data and the complexity of the factors affecting the health of middle-aged and old residents, there may still be the problem of missing variables. All these will lead to endogenous problems in the model.

TABLE 6 | Benchmark regression results.

Variable	*self_HL*		*actual_HL*	
	Coefficient	**Odds ratio**	**Coefficient**	**Odds ratio**
PITI	0.0099***	1.0100	0.0086***	1.0087
	(0.0018)		(0.0019)	
gender	−0.1665**	0.8464	−0.8318***	0.4353
	(0.0744)		(0.0788)	
age	−0.0221***	0.9787	−0.0628***	0.9392
	(0.0026)		(0.0027)	
edu	0.0391***	1.0399	0.1077***	1.1137
	(0.0129)		(0.0138)	
marriage	0.0495	1.0507	0.1408*	1.1512
	(0.0719)		(0.0734)	
sleep	0.1714***	1.1870	0.1354***	1.1450
	(0.0128)		(0.0136)	
smoke	−0.3001***	0.7408	−0.2983***	0.7421
	(0.0704)		(0.0745)	
drinking	−0.2521***	0.7771	−0.2460***	0.7819
	(0.0287)		(0.0306)	
physic	0.5765***	1.7798	1.0791***	2.9420
	(0.0975)		(0.0997)	
insurance	−0.1366	0.8723	−0.0797	0.9234
	(0.1447)		(0.1472)	
health_ep	−0.0066	0.9934	−0.0031**	0.9969
	(0.0042)		(0.0014)	
health_ch	0.1992***	1.2205	0.0573***	1.0589
	(0.0198)		(0.0215)	
urban	0.2613***	1.2986	0.1424***	1.1530
	(0.0474)		(0.0493)	
Pseudo R^2	0.0434		0.1177	
N	7,533		7,533	

*Robust standard errors in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.*

To solve the endogenous problem of the model, we choose the IV-Ordered probit regression model. With reference to Zhao (53), we select the lag period of PITI as an instrumental variable, including one lag period ($PITI_{t-1}$) and three lag periods ($PITI_{t-3}$). On the one hand, the level of public environmental information in cities generally has "inertial" characteristics, so the PITI in the lag period is significantly related to the PITI in the current period. On the other hand, the PITI in the lag period is difficult to directly impact the health of the current middle-aged and old residents.

Table 10 reports the regression results after dealing with the endogenous problem. From this table, we find that the Wald test of the two instrumental variables passed the 1% significance test, thereby rejecting the null hypothesis of weak instrumental variables. After the instrumental variables are added, the estimated coefficients of the core explanatory variable *PITI* for the explained variables *self_HL* and *actual_HL* are still significantly positive, reconfirming the conclusion that there

TABLE 7 | Stepwise regression for *self_HL*.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
PITI	0.0130***	0.0132***	0.0110***	0.0115***	0.0104***	0.0099***
	(0.0017)	(0.0017)	(0.0017)	(0.0018)	(0.0018)	(0.0018)
	[1.0130]	[1.0133]	[1.0110]	[1.0115]	[1.0104]	[1.0100]
Demographic characteristics	No	Yes	Yes	Yes	Yes	Yes
Living habits	No	No	Yes	Yes	Yes	Yes
Medical behavior	No	No	No	Yes	Yes	Yes
Health lever in childhood	No	No	No	No	Yes	Yes
Urban or rural residents	No	No	No	No	No	Yes
Pseudo R^2	0.0027	0.0180	0.0348	0.0372	0.0418	0.0434
N	7,875	7,793	7,791	7,590	7,533	7,533

*Robust standard errors in parentheses. Odd ratio in brackets. *p < 0.1, **p < 0.05, ***p < 0.01.*

TABLE 8 | Stepwise Regression for *actual_HL*.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
PITI	0.0091***	0.0111***	0.0096***	0.0096***	0.0088***	0.0086***
	(0.0017)	(0.0017)	(0.0018)	(0.0018)	(0.0019)	(0.0019)
	[1.0092]	[1.0111]	[1.0096]	[1.0096]	[1.0089]	[1.0087]
Demographic characteristics	No	Yes	Yes	Yes	Yes	Yes
Living habits	No	No	Yes	Yes	Yes	Yes
Medical behavior	No	No	No	Yes	Yes	Yes
Health lever in childhood	No	No	No	No	Yes	Yes
Urban or rural residents	No	No	No	No	No	Yes
Pseudo R^2	0.0016	0.1009	0.1276	0.1267	0.1172	0.1177
N	8,429	8,313	8,313	8,089	7,533	7,533

*Robust standard errors in parentheses. Odd ratio in brackets. *p < 0.1, **p < 0.05, ***p < 0.01.*

TABLE 9 | Regression results of OLS and ordered probit models.

Variable	OLS		Ordered probit	
	self_HL	***actual_HL***	***self_HL***	***actual_HL***
PITI	0.0052***	0.0028***	0.0058***	0.0052***
	(0.0009)	(0.0006)	(0.0010)	(0.0011)
Control variables	Yes	Yes	Yes	Yes
R^2/Pseudo R^2	0.1045	0.2271	0.0419	0.1184
N	7,533	7,533	7,533	7,533

*Robust standard errors in parentheses. * p < 0.1, **p < 0.05, ***p < 0.01.*

TABLE 10 | Regression results of IV-Ordered probit.

Variable	IV = $PITI_{t-1}$		IV = $PITI_{t-3}$	
	self_HL	***actual_HL***	***self_HL***	***actual_HL***
PITI	0.0052***	0.0072***	0.0107***	0.0099***
	(0.0012)	(0.0013)	(0.0016)	(0.0017)
Control variables	Yes	Yes	Yes	Yes
Weak-IV: Wald test	18.57***	32.65***	44.23***	32.91***
N	8,658	8,658	8,658	8,658

*Robust standard errors in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.*

is a significant positive relationship between environmental information disclosure and the health of middle-aged and old residents.

Regional Differences

To study whether there are regional differences in the impact of environmental information disclosure on the health of middle-aged and old residents, we divided all samples into three categories: eastern, central, and western. The eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. The central region includes Heilongjiang, Jilin, Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan. The western region includes Guizhou, Yunnan, Shaanxi, Inner Mongolia, Guangxi, Chongqing, Sichuan, Qinghai, Gansu, Ningxia and Xinjiang.

Table 11 shows the Ologit regression results of different regions. We select the explained variable *actual_HL* with better fitting effect. The results in **Table 11** show that similar to the estimated results of the total sample, the estimated coefficients of *PITI* in different regions are all positive. However, only the

TABLE 11 | Ologit regression results of different regions.

Variable	Eastern region *actual_HL*	Central region *actual_HL*	Western region *actual_HL*
PITI	0.0016	0.0269***	0.0071
	(0.0031)	(0.0054)	(0.0049)
Control variables	Yes	Yes	Yes
Pseudo R^2	0.1191	0.1213	0.1242
N	3,303	2,124	2,106

*Robust standard errors in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.*

estimated coefficients in the central region are significant, and the estimated coefficients in the eastern and western regions have not passed the significance test. This outcome shows that the impact of environmental information disclosure on the health of middle-aged and old residents is mainly manifested in the central region of China.

DISCUSSION

(1) Forcing local governments to strengthen environmental management and improve the ecological environment is one of the roles of environmental information disclosure, which is conducive to improving the health of middle-aged and old residents. For a long time, China has been regarded as "information-poor", and the country has strong control over economic development and information dissemination (54, 55). In the past 10 years, China's control of information and information processes has undergone major changes, especially in the field of environmental governance (56). The central government allows or even actively promotes the disclosure of environmental information and media reports to fight against powerful local polluters—usually some high-polluting manufacturing companies (34). However, local authorities generally do not support this environmental transparency because manufacturing companies are often an important source of tax revenue for local governments (57). With the openness of environmental information and the freedom of more media to report environmental disasters and protests, it is possible to resist the distortion of environmental information by local and regional authorities and force local governments to conduct environmental governance. The central government is likewise paying more and more attention to ecological and environmental issues in assessing the work and promotion of local officials, and the level of local environmental information disclosure is one of them (58). In the international community, The Chinese government has been calling on all countries to pursue innovative, coordinated, green and open development for all. The Chinese government has also been making its own contribution to controlling carbon emissions and addressing global climate change. Therefore, in the face of inspections and assessments from the central government and public supervision, local governments also form an accountability mechanism for environmental governance similar to the reverse effect (59). By increasing the transparency of environmental information, the central government, the general public, and the news media can strengthen the multiple accountabilities of local governments, thereby forcing them to strengthen environmental governance.

(2) Promoting companies to reduce pollution emissions and improve the ecological environment is another role of environmental information disclosure, which is also conducive to improving the health of middle-aged and old residents. Such disclosure can increase the environmental awareness of corporate management and stimulate changes in the production process (60). According to the theory of organizational legitimacy (61), pollutant companies are subject to pressure from regulatory agencies and public opinion when facing environmental information disclosure. If corporate behavior deviates from social values, then corporate legitimacy will be threatened and public policies that are unfavorable to corporate development will be incurred. To avoid these situations, companies will further strengthen technological upgrading and information disclosure, bear their due economic and social costs, reduce pollutant emissions, and improve their environmental efficiency. In addition to regulatory pressures, the need to improve financial performance also forces companies to take environmental protection actions (62). Environmental information disclosure can reduce information asymmetry between companies and investors, increase investors' trust in companies, and build social confidence (63, 64). It can also improve the company's green reputation (65). A good reputation can improve the company's relationship with stakeholders and attract more consumers (66), which will positively impact its financial performance.

(3) Environmental information disclosure is also an important driver of health behavior and decision-making changes among middle-aged and older residents. The first is by avoiding health risks. Passively perceiving changes in environmental pollution and strengthening environmental information disclosure can play certain roles in early warning. Since the physical health of middle-aged and old residents is more susceptible to threats than that of young people, as a rational individual, the former will quickly take measures against environmental pollution. For example, timely disclosure of air pollution information can enable middle-aged and old residents to reasonably plan outdoor activities based on environmental pollution state. Smog alarms issued through media channels, such as television, radio, and newspapers, can significantly reduce their daily attendance and outdoor activities (67, 68). The second is by actively participating in environmental protection. Public participation in environmental governance must be based on a certain amount of environmental information; however, the public will pay a lot of private costs, such as time and money, to collect relevant environmental information (69). Environmental information disclosure can allow middle-aged and old residents to understand the surrounding environmental conditions and existing problems, point out the direction for participating in

environmental governance, and reduce the difficulty of their participation in environmental governance. Such disclosure can improve the scientific understanding of environmental issues and ecological protection awareness of middle-aged and old residents (70). At the same time, it helps them increase their trust in the government, thereby increasing their enthusiasm to participate in environmental governance. Furthermore, in the field of public health, non-government actors such as private sectors, social society, philanthropy, academia play their role to improve the health of all. The implementation of the environmental information disclosure system also helps to enhance their motivation and convenience to participate in environmental governance. The third is by rising health care expenditures. A study based on data from Indian households shows that households who are told their drinking water may be contaminated will increase their spending on water purification (71). The environmental information disclosure system can also bring the same effect. It can inform middle-aged and old residents whether the surrounding environmental pollution is severe. When environmental pollution is serious, middle-aged and old residents increase their health care expenditures to protect their health, such as purchasing protective equipment, sports equipment, and health care drugs.

(4) The impact of environmental information disclosure on the health of middle-aged and old residents also has significant regional heterogeneity. Specifically, the impact is mainly reflected in the central region of China. The reason for this result may be derived from the high pollution in central China. Compared with the eastern and western regions, the central region of China has a large labor force and low labor costs. Meanwhile, the cost of land in the central region is lower, and there are more relaxed environmental regulations. Enterprises with high pollution are more willing to build factories in the central region. Therefore, the central region has become the most concentrated area of environmental pollution in China and is facing more severe environmental pollution challenges. Official statistics from the Chinese government show that in terms of waste water, waste gas and industrial solid waste, the central region has significantly higher emissions than the eastern and western regions, with Shanxi and Anhui provinces experiencing particularly severe pollution. Enhancing the disclosure of environmental information can restrain the pollutant discharge behavior of polluting enterprises and promote the process of environmental pollution control in the central region. Therefore, the health level of middle-aged and old residents in the central region is more prominently affected by environmental information disclosure.

CONCLUSION

Based on the data of PITI and CHARLS in China, this study uses the Ologit regression model to explore the impact of environmental information disclosure on the health of middle-aged and old residents. Results show that environmental information disclosure can improve the health of middle-aged and old residents. After the robustness test and endogenous problem handling, this conclusion still holds. Estimation results of the Ologit regression model show that when PITI increases by 1 unit, the probability of improving the self-reported health level and actual health level of middle-aged and old residents increases by 1 and 0.87%, respectively. In addition, due to different levels of environmental pollution, the impact of environmental information disclosure on the health of middle-aged and old residents has significant regional heterogeneity. Specifically, the impact is mainly reflected in the central region of China.

In order to improve the health level of middle-aged and old residents, we suggest that the Chinese government should further improve the environmental information disclosure system, and take the reception rate and satisfaction rate of residents as important indicators to evaluate the implementation effect of the environmental information disclosure system. Meanwhile, the government should timely adjust the content and form of environmental information disclosure according to the needs of residents. In addition, the government also needs to formulate different environmental information disclosure goals according to the actual characteristics of environmental pollution in different regions.

According to the classification of the three actors of government, enterprises, and individuals, we discuss the specific mechanism of this effect and present in three paths: forcing local governments to govern the environment, promoting enterprises to reduce pollution, and influencing individuals to make behavioral decisions. However, we did not test these mechanisms with mathematical models, which is also the specific direction for our future research.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: Data of CHARLS-2018 are available at http://charls.pku.edu.cn/, and data of PITI are available at http://www.ipe.org.cn/.

AUTHOR CONTRIBUTIONS

XY and WS: conceptualization and data collection. XY: analyzed data and writing—original draft preparation. XY and SL: writing—review and editing. All authors contributed to the article and approved the submitted version.

FUNDING

This research was funded by the Natural Science Foundation of Zhejiang (No. LQ22G030002), the National Social Science Fund of China, (No. 19AZD004), the National Natural Science Foundation of China (No. 71874092), and K.C. Wong Magna Fund in Ningbo University.

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frontiers in Public Health

METHODS
published: 18 March 2022
doi: 10.3389/fpubh.2022.648593

Bio-Ethics and One Health: A Case Study Approach to Building Reflexive Governance

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Surveillance programs supporting the management of One Health issues such as antibiotic resistance are complex systems in themselves. Designing ethical surveillance systems is thus a complex task (retroactive and iterative), yet one that is also complicated to implement and evaluate (e.g., sharing, collaboration, and governance). The governance of health surveillance requires attention to ethical concerns about data and knowledge (e.g., performance, trust, accountability, and transparency) and empowerment ethics, also referred to as a form of responsible self-governance. Ethics in reflexive governance operates as a systematic critical-thinking procedure that aims to define its value: What are the "right" criteria to justify how to govern "good" actions for a "better" future? The objective is to lay the foundations for a methodological framework in empirical bioethics, the rudiments of which have been applied to a case study to building reflexive governance in One Health. This ongoing critical thinking process involves "mapping, framing, and shaping" the dynamics of interests and perspectives that could jeopardize a "better" future. This paper proposes to hybridize methods to combine insights from collective deliberation and expert evaluation through a reflexive governance functioning as a community-based action-ethics methodology. The intention is to empower individuals and associations in a dialogue with society, which operation is carried out using a case study approach on data sharing systems. We based our reasoning on a feasibility study conducted in Québec, Canada (2018–2021), envisioning an antibiotic use surveillance program in animal health for 2023. Using the adaptive cycle and governance techniques and perspectives, we synthesize an alternative governance model rooted in the value of empowerment. The framework, depicted as a new "research and design (R&D)" practice, is linking operation and innovation by bridging the gap between Reflexive, Evaluative, and Deliberative reasonings and by intellectualizing the management of democratizing critical thinking locally (collective ethics) by recognizing its context (social ethics). Drawing on the literature in One Health and sustainable development studies, this article describes how a communitarian and pragmatic approach can broaden the vision of feasibility studies to ease collaboration through public-private-academic partnerships. The result is a process that "reassembles" the One Health paradigm under the perspective of global bioethics to create bridges between the person and the ecosystem through pragmatic ethics.

Keywords: pragmatic ethics, program governance, data access, One Health surveillance, responsibility, antimicrobial use (AMU), sustainable development

OPEN ACCESS

Edited by:
Ulrich Laaser,
Bielefeld University, Germany

Reviewed by:
Sonja Hartnack,
University of Zurich, Switzerland
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Specialty section:
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

Received: *31 December 2020*
Accepted: *31 January 2022*
Published: *18 March 2022*

Citation:
Boudreau LeBlanc A, Williams-Jones B and Aenishaenslin C (2022) Bio-Ethics and One Health: A Case Study Approach to Building Reflexive Governance. Front. Public Health 10:648593. doi: 10.3389/fpubh.2022.648593

INTRODUCTION

The greatest health, social, and environmental challenges of the twenty-first century, such as antibiotic resistance, zoonotic pandemics, and climate change, require a "complexification" of monitoring and management programs (1). One Health aiming at the convergence of human, animal, and environmental health seeks to operationalize this complexity—in terms of contextualization, participation, and adaptation—through the integration of adaptive governance systems in evaluation, surveillance, and intervention (2–4). However, such programs should also be based on the practice of empowerment ethics: a self-critical examination, a receptivity to criticism, and a critical duty to change in order to judge and implement "good" learning for a "better future." As understood by Van Rensselaer Potter (1911–2001; who coined the term bioethics in 1970), empowerment must lead to responsibility as a duty, not only to autonomy as a right for self-governance which tends to separate the singular will from biological facts (5, 6). First, em-power (*in/within* power) means managing and preventing the power, knowledge, and interest dynamic that transcends and modulates people and "community-will" and behavior: a "bottom-up" approach. Second, empowerment must lead individuals and communities to make their own changes, as autonomous and self-determining agents who acknowledge local values and constraints as criteria for change. Third, power must lead to awareness of our individual and social actions, which should also lead to self-responsibility and even to accountability mechanisms: an "abductive" approach (7)[1].

Data sharing processes, biosurveillance programs, and multiscale analysis are techno-intellectual systems; they are examples of Edgar Morin's complexity concept. Managing complex systems requires pragmatic methodologies and ethics (9) because the willingness of people to consent to and participate in these systems changes over time (10, 11). An ethic (as a code) is useful both for transparency and as a means to produce a climate of trust that is suitable for discussion, while ethical analysis (as a methodology) is a key component to avoid the emergence of oppressive powers, to reduce bias, and to envision a "better future" (12, 13). For instance, feedback from One Health surveillance programs such as benchmarking is appreciated by practitioners where it improves their practices, until it raises ethical issues, notably, risks of bias and confidentiality breach. Empowerment ethics (as a discipline), then, is about finding ways to communicate to produce a collective narrative that gives meaning and orientation to actions and is especially important when there is a diversity of terminologies and interdisciplinary perspectives. In this view, communication must go beyond the person-to-person exchange and become a collective process (14).

Predictive and mechanistic models are no longer sufficient to address health problems in all their complexity (15). Callon et al. (14) propose that we move from risk assessment and management to a social process that integrates more broadly uncertainty. One Health should therefore move its problem-solving strategies "upstream," before program ideation, which we will call here the "assemblage" of its knowledge, notably, its technologies, its methods, even its paradigms (16, 17). Such One Health ethics, which would progress through communication and knowledge systems, would enable stakeholders to question and advance their understanding and positioning. However, managing the "cross" thematic (e.g., human, animal vs. environment studies), the "inter" disciplines (e.g., medicine, technology, and law), the "trans" sectorial (e.g., the relationship between experts and non-specialists), and the "multi" scale viewpoints (e.g., human, beings, and things as organizational units) is a fundamental barrier to the successful implementation of One Health programs (18–20).

The objective is to lay the foundations for a methodological framework in empirical bioethics, the rudiments of which have been applied to a case study to building reflexive governance in One Health. This case made it possible to study the functioning of empowerment ethics in the development cycles of One Health surveillance programs. The proposed case sought to implement an antibiotic use surveillance program in animal health (2018–2021) in Quebec, Canada. Data from this surveillance system in public health could allow both scientific research and informed decision-making. The research question here, in bioethics, is about the promotion and education of critical thinking in technology and health, not only of scientists and policymakers but of all stakeholders. Building on a pragmatic approach to bioethics, this reasoning is driven by, first: How could empowerment ethics ease the "bridging" between cognitive and collective? From a synthesis of One Health methodologies and paradigms, the reasoning continues with a framework laying out the theoretical rudiments for a hybrid method to understand: How can we embed person-to-person dialogue in a collective assemblage to engage social groups in a negotiation process? Dialogue is supported by reflective critical thinking approaches, while social negotiation moves this cognitive to the level of collective interaction supported by ethical deliberation approaches. Finally, learnings from the case study will give answers to How can a community of beings and things become "reflexive," conscious, and responsible, i.e., the "ought to be" empowered?

SITE AND APPROACH

Case Study of Antimicrobial Surveillance and Data Governance

Since 2017, the Government of Quebec has been considering developing surveillance programs that integrate efforts in health prevention between several ministries and sectors (see the Government Policy on Health Prevention; GPHP). This type of policy could be improved by its connection with several advanced theories in various fields that converge in practice under the perspective and terminologies of One Health and sustainable development. A challenge for One Health, in such a policy context, is to deepen the decision-maker's understanding of the pertinent theories while avoiding reduction to a set of

[1]Abduction and inquiry (a "top-down / bottom-up" approach) are key processes from pragmatism (C. S. Peirce 1839–1914 and J. Dewey 1859–1952) to bridge behaviors, norms, and beliefs, but requires ethics to function properly (8).

expert buzzwords or jargon that then complicate translation into practical terms (21).

One of the policy objectives set by the Government was to develop a well-articulated program that had community-based meaning and criteria (e.g., feasible and acceptable, understood as useful, and sustainable) for a surveillance system of antibiotic use in animal health (agriculture and pets). Its program arose in a social context where several sectors, particularly in human, animal, and environmental health, had already implemented initiatives dealing with outbreaks, pharmaceuticals, and, notably, antimicrobial governance based on systems of information and communication technologies (SICT) used for surveillance purposes. In animal health, different committees, associations, and groups are involved in leading these reflections through participation in formal and informal working groups. These activities aim to produce detailed application procedures that would then be laid out in an action plan for the management of antibiotic use, surveillance, and governance for all sectors of veterinary practice and food production[2]. Many initiatives were more local (microscale) and launched by individuals or groups affiliated with the industry, academia, and professional associations, while others were broader (macroscale), and initiated by governments and civil society as networks (market, culture, values, etc.). The resulting initiatives are designed to push for change on both a micro and macro scale. But for such change to be effective, it requires a mixture of approaches, including both "top-down" political incentives (regulations, financing, and infrastructure) and "bottom-up" processes, including democratic mechanisms.

In light of these different initiatives, the *Ministère de l'agriculture, des pêcheries et de l'alimentation* (MAPAQ) mandated a feasibility study of the implementation of a surveillance program on the use of antibiotics in animals in Quebec (2018–2021). Several recommendations emerged from the resulting consensus-building process (2019–2020) within the veterinary and agricultural community, notably:

1. To build data systems and information platforms and their use based on trust,
2. To co-construct a common normative language,
3. To design a collaborative governance regime to shape the functioning of the program.

Aiming to implement a methodology for this collaborative collective thinking, the multidisciplinary team in charge of the feasibility study made a distinction between "consultation" and "concertation" to unpack the consensus-building nature of the methodological process. The consultation aims to gather information from a group to inform experts in developing the "best" model possible (the feasibility aspect), while concertation seeks for consensus among a group to deliberate about which criteria are "best" (values and vision), in order to give an acceptable orientation to the developing model (see here the clear distinction between descriptive and appreciative knowledge further developed in the last section).

The concertation phase of the feasibility study, which began with 60 representatives, eventually brought together 100, an extensive recruitment process aimed at saturating the perspectives covered by the different sectors of activity (industry, academia, government, association, order, etc.), practice (pork, poultry, small and large ruminants, pets, and sports animals), and professions (breeders, veterinarians, nutritionists, researchers, informatics experts, etc.). The two concertation events made it possible to collectively deliberate on the overall vision and were then followed by 12 consultations that brought together different stakeholders in small groups (6–16 participants per group) to deepen the discussion. Subsequent focused individual interviews made it possible to add reflexive details to the perspectives (challenges and facilitators) of key actors involved in the process (e.g., data, software, IT support providers). Human and environmental sectors (professional, academic, political, and industrial) were not the focus of the discussions; instead, the focus was on the ethical challenge of implementing a new technosocial program and developing a policy to manage the use of antibiotics in animal health. Nevertheless, many of the participants were invited to group discussions and interviewed separately to further explore their views on how the animal health situation is nested within the larger context of One Health. Ethics approval was received for the research phase of this project from the University Research Ethics Committee (anonymous); all participants were informed of the nature and scope of the project, the confidentiality mechanisms in place, and gave their consent to participate.

A Pragmatic Bioethics Approach

One of the notable challenges of contemporary methodologies is to account for multi-scale relationships, building a bridge between the individual, the social, and the global. Ten Have (22) introduces the community perspective as an appropriate approach to operating global bioethics. By examining recent conceptual advances in pragmatic ethics and empirical bioethics, we propose here the operation of a community-based action-research (translated in action-ethics). According to Jonathan Ives (23) synthesis of methodologies in empirical bioethics (24, 25), an ethical analysis of a complex situation should be reflexive and focus on the empirical case under study, and not be biased by it, and so risk (over)valuing preexisting injustices rather than criticizing them (26). A multidisciplinary team of academics (veterinary medicine, bioethics, and law) and practitioners (veterinary, farmers, millers, association, and industry) contributed extensively to the empirical bioethics research project, which was embedded within and thus part of the above-mentioned feasibility study.

The team located at the *Faculté de Médecine Vétérinaire* at the *Université de Montréal* (FMVUM) was mandated by MAPAQ to conduct a large-scale empirical and social project. By reviewing, commenting upon, and critiquing the rudiments of this philosophical model, both the team and participants

[2]For instance, the Stratégie québécoise de santé et de bien-être des animaux proposed an antimicrobial governance plan for all veterinary practices, the *Comité consultatif sur l'utilisation judicieuse des médicaments* for the pork industry and the professional Order as well as academic institution as initiated their own reflection. Each act on different domains (veterinary sectors), scales (professional advice up to national policies), and levels (from descriptive data to prescriptive commend or evaluative thinking).

contributed to testing and enriching the model, as intended by *good* reflective practice. As an employee for this project, one of the authors, Boudreau LeBlanc (a Ph.D. student and empirical bioethicist in training), was given the task to develop a model to manage the ethical challenges with deploying consultation and concertation processes and to ensure the reflexivity of the experts and the deliberation of the collective (e.g., power relations, naturalistic, and philosophical reasoning biases). One solution to the challenge of bridging reflexivity and deliberation was to include the micro, meso, and macroscales in discussions, although this also introduced other ethical challenges, namely the subjectivity of each actor (e.g., their values, knowledge, and interests). Thus, it was obvious that a collective ethic was needed to set ground rules so that the actors could cooperate and co-construct the governance system. The feasibility study (2018–2021) conducted in Quebec, Canada, to evaluate the possible implementation of a monitoring system for the use of antibiotics in veterinary medicine was thus an ideal opportunity to study *in situ* how such a collective ethic could be implemented in a complex system in a way that leads to empowerment (27, 28).

Ethics is crucial to guiding new means of collaboration through public-private-academic partnerships, but it also requires empirical methodologies such as those developed in bioethics and pragmatism. Pragmatic ethics is about negotiating conflicting positions that emerge from empirical situations (within the community) and are made accessible through philosophical reasoning (26, 29). Ethics of science means (here, as a discipline) supporting the scientific community to question itself, individually as the responsible conduct of researchers, but also collectively through critiques of the nature of scientific research (in general and related to specific projects). Ethics (as in codes) is involved in the development of appreciative criteria and knowledge to judge conduct, evaluate the purpose, and propose appropriate governance mechanisms. Such an understanding of ethics could favor trust and lead to an agreement between experts and the community, which could then accelerate change. However, any criteria also need to progress through time *via* both rational reflexivity (a cognitive process) and collective deliberation (a social process). Without pragmatism in the ethics of science, researchers and communities will struggle to produce effective and adaptive networks, norms, and actions because the interests of the various stakeholders (as social or disciplinary) will not be articulated or aligned (5, 6).

A practice of empowerment ethics should be developed by and for a community (30, 31). In this Potterian One Health framing, empowerment ethics is presented as an alternative mode of governance that returns power to the key stakeholders involved, so that they can become actors of and responsible for the changes with which they will live (6). Such an understanding of ethics could provide a valuable foundation on which to build collaborative governance regimes that transcend academic, industrial, and public service limitations (32, 33). One of the cores aims of empowerment ethics is to build and maintain the trust of the key stakeholders involved in the program (34, 35). According to Davet et al. (36), three methodological processes should be used:

1. Design a practical model of change,
2. Set up a collaborative governance structure early in the thinking process,
3. Co-construct a common language to give purpose to, and a framework for, points 1 and 2.

As theorized by Latour (16), such a method necessitates a socio-episteme-methodological approach, the sort which is embodied in One Health and, more broadly, in bioethics (37). In practice, such an approach needs to be distributed at various scales of observation, at all levels of knowledge, and across several analytical dimensions, explained by Callon et al. (14) as three intertwined operations of translation and by Latour (16) as the metrological manner of constructing scientific standards (see the synthesis tool in the last section).

This ethics-science-society organizational approach highlighted in Beever and Whitehouse's (37) work in Potterian bioethics is conceptually close enough to Morin's philosophy to be qualified as a "Penser Global" ("Think Global," not "worldwide," 2015) or more deeply to fall under the paradigm of human complexity (38), and requires an extended understanding of the sciences and an answer to the question: what is "truly" feasible? In a similar vein, the UN (39) has called for a science of sciences to develop an ecosystem of knowledge as part of ongoing critical thinking about science and policy. In this view, science must be seen as a complex (eco)system for which the "rules of the game" change over time as society "evolves" (e.g., changes in political, social, and physical laws). Consequently, we must also be cognizant of emerging biases and inequities, and so develop a practice in ethics of sciences and as an "ethic of ethics" based on a community-based empowerment ethics practice (40). Potter (41) highlighted the importance of supporting such collective ethics of science as a frame to determine what is "feasible" (i.e., the right knowledge and technical standards). This practice of ethics should thus be understood as a form of pragmatic "action-ethics" grounded in a strong critical thinking process that emerges from people and the social. This action-ethics practice combines several approaches proposed by empirical bioethics scholars (26, 29): "inter-ethics" (42), "in-action ethics" (43), and "ethics ecosystem" (44).

THE FRAMEWORK

Assembling the Methods

To build reflexive governance for SICTs development, we propose a community-based action-ethics methodology. The methodology bridges expert evaluation and collective deliberation in a way to empower individual stakeholders and engage group leaders (**Figure 1**). Project management in *Research and Development* must shift to a more integrative practice, coined here as adaptive *Reflective-Evaluative-Deliberative* cycle.

Evaluation (literally "the action of defining the value of") is a key technique for bridging philosophy, science, and society through practical reasoning methods. Evaluation and deliberation must be conceived as independent methods given their distinct philosophical criteria and end (epistemology and

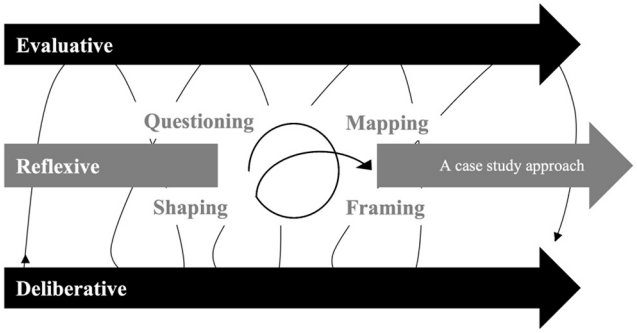

FIGURE 1 | Framework in research and innovation to building reflexive governance for the responsible development of systems of information and communication technologies, hybridizing three types of reasoning are key to "reassembling" scientific paradigms in practice: 1. Evaluative as descriptive and traceable, 2. Deliberative as appreciative and prospective, and 3. Reflexive as knowledge balancing (1–2) to responsible policy. Reassembling is a "complexus" process (literally "being woven together"), here seen as an adaptive cycle and through the lens of the Huxtable and Ives framework in bioethics to support project management: 1. "Mapping" the ideas to generate a hybrid ethical theory, 2. "Framing" to be reliable to a case, and 3. "Shaping" a proper (micro) normative theory for change. We highlight the importance of ever questioning the whole process.

teleology). To do so, reflexivity tools are crucial to avoid logical fallacies and to deepen and enrich the program value. However, these three methods benefit from being driven in parallel as interdependent methodologies (23, 42). Therefore, the expertise in One Health should be based on more advanced knowledge of social science and philosophy, which should lead to an applied "social ethics." The bioethicist can help bridge political, social, and scientific insights within and outside organizations (42). These insights must be based on empirical observations and expert advice, namely a "co-construction" perspective hybridizing qualitative methods such as Delphi, concertation, participative study, and focus groups[3].

Deliberation (literally "to discuss collectively in order to decide") is a common reasoning process in day-to-day life. Deliberation aims at collectively examining, justifying, and questioning reasoning. However, political and professional deliberations should be about ethical justification, not scientific or political ones, or any private interest. Deliberation can be based on critical and evaluative reasoning, which would lead to a (*disciplined*) form of "collective ethics." Collective ethics could become an end for deliberation. Deliberative reasoning has a foot in the political and scientific "arena," both of which may or may not be conducted ethically. Collective ethics seeks to establish "ground rules" as starting principles that are analyzed from multiple angles (all stakeholders), including from the sciences and society as a "hybrid forum" (14)[4]. Deliberation benefits from qualitative methods (including those mentioned above), especially when rooted in political and humanistic approaches, such as hermeneutics (42). However, deliberation must not intend to "test" ideas or even describe a group's narrative, as would be the case of these methods in empirical sciences. The aim is to *reassemble*, seek consensus and acceptability on the proposal, and deepen the collective reasoning. Expert understanding and scientific knowledge must be mobilized in recognition of their descriptive and analytical value during such reflective processes.

Reflexivity, as the quality and method for critical thinking, connects the real world (empirical) to abstract reflection (intellectual), allowing feedback from both sides: evaluation and deliberation. But reflexivity is tied to the (epistemological) challenges of both philosophy and science, to which pragmatism provides some answers. Judging reflexive thoughts is a matter of dialogues, integrity, and trust, even of bidirectional relationships, of a continuous search for consensus, and of collective duty to empower people to question these "thoughts." Expertise from philosophy or science must be careful not to become a (normative) dictature (40), even under urgent calls for sustainability, precautionary, solidarity, and responsibility in public health (11, 48–50). The competency of experts must be balanced with humility and compassion (51), or localism and experimentalism (52). The objective of reflexivity in pragmatism is to find *ever better* courses of action, the quality of which is established in light of the *future* (feedbacks). This "prospective science" is intellectualized as experiential learning (yet past), with the aim of archiving the common ground for cooperation, such as a vision, models, and theories (even formal agreements) of change (5, 39, 53).

Apply a Balancing Approach

Following Huxtable and Ives' (26) framework in empirical bioethics, the process is divided into three phases to organize the reasoning:

1. "Mapping" the ideas to generate a hybrid ethical theory,
2. "Framing" to be reliable to a case,
3. "Shaping" is a proper (micro) normative theory for change.

In *A Companion to Bioethics* (54), John Arras understands this *framing* in bioethics as "casuistry," an approach in ethics: "the [technics] of applying abstract principles, maxims or rules to the concrete case." The "empirical case" (as used here) is a social collective on the edge of transformation, meaning to be reorganized or "reassembled" according to Latour's work (16) based on a unifying issue, here antimicrobial governance and digitalization. This Latourian perspective embeds the observer in the systems he is observing, which opens the possibility of a case study in empirical bioethics, focusing on the (intellectual) system of values characterizing and contextualizing these observers (based on a Ph.D. project in bioethics). To propose an ethical strategy for "managing" this system of values, which means deepening and seeking consensus among various interests, we

[3]Depending on his·er background, the bioethicist can also reinforce networking, designing, applying, and synthesizing. As illustrated by the idea of "living labs" put forward by the International OBVIA, a living lab applied to bioethics can help manage power relationships, mainly those driven by interests and values (45), from an understanding of responsible conduct procedures and ethics in academic and governmental researches.

[4]See the Agri-Food AI Ateliers initiative (46) or Montréal Declaration for a Responsible Development of Artificial Intelligence deliverative processes (47).

adopt the logic of adaptive cycles in management, the one that gives rise to the perspective of adaptive governance (55).

Critical reflexivity is understood here as "balancing" reasoning. Reflexivity is a negotiating process between empirical data from interdisciplinary methods and rational insight from philosophical methods in order to find feasible solutions and long-term acceptable actions (6, 23). "Balancing" means having facts and values as two samples for which we do not know *a priori* their weight. We must experience this balancing (as an ongoing process) to ground the normative knowledge that should support decision-making. "Fact" means knowledge and empirical observations (*in situ*: resources, capacities, power, and will), while "value" is about philosophical questioning and self-critical reasoning. Values are given to qualifying, notably uncertainty, bias, even the usefulness and successfulness of decisions (56). Theories of value, as academic knowledge, archive notable critical reasoning paths. However, values, criticism, and reflexivity are also subjective.

Reflexive balancing, coined by Ives (23) with Heather Draper (25), is an ethical (meta)analysis combining methodology for interdisciplinary and critical reflexivity. The outcome can support self-governing processes that empower the community. At the collective level, *reflexive balancing* must begin at the start during initial planning, sampling, and questioning (**Figure 1**). This upstream ethical reflexivity and expertise have included the active role of FMVUM team members to conduct the interdisciplinary methodology. This means diversifying the disciplinary assets at the start; here meaning expertise in ethics, laws, technologies, and medicines, and more broadly community representatives. Note that facts and values are not dependent—as in "reflexive equilibrium" (23, 57)—but interdependent through the reasoning process. For example, sometimes facts justify actions that go far beyond what is acceptable and thus go against accepted human values; their application changes the "rules of the game." Alternatively, values can justify change prior to evidence, as articulated in the principles of precaution, solidarity, or responsibility.

Social negotiation, a key concept of the deliberation reasoning (58), can support ethical analyses when applied to the evaluation of multi-actor systems of values as a "collective thinking process." Ethical negotiation is enriched by co-construction approaches conducted at all steps of the program development and by acknowledging multiple scales of translation: here the expert, team, and community (14). At the expert level, the approach of Abma et al. (42) to bioethics was used to interact with actors (the Ph.D. student as a formal member of the FMVUM team) to deepen their understanding and positioning. At the team level, Samuel et al. (44) coined the model of "The Ethics Ecosystem" to empower stakeholders in the development of the governance system structure, functioning, and purpose, notably the influence of allocation of financial resources, conflicts of interest and shared responsibilities. At the (collective and biotic) community level, Ives' (23) methodology for empirical ethics provides guidance on how to negotiate stakeholder values and avoid fallacious reasoning through a reflexive, interdisciplinary, and pragmatic balancing method.

In summation, how to connect reflexivity and deliberation in One methodology with One (collective) goal? Where should ethics occur in decision-making processes to empower critical thinking from individuals to the whole organization? Is it by the mandating government (a department, e.g., MAPAQ), the responsible team (within the university, e.g., FMV), or individuals (representatives of private interests)? The three kinds of reasoning—reflexive, evaluative, and deliberative—integrate distinctive approaches from empirical bioethics into the project management process (**Figure 1**). All three steps refer to methods that have distinct philosophical standpoints (i.e., qualitative criteria of scientificness and ends). For instance, deliberation is about collective discussions and consensus-seeking, while evaluation refers to critical analysis (scientific, political, economic, etc.), but must also be ethical, meaning self-critical reflexivity. This linkage implies the opening of a dialogue "in the field" between experts, here in veterinary practitioners, epidemiology, data science, technology governance, etc., with different social perspectives (professional orders, industrial associations, interest groups, universities, government, etc.). In the spirit of the community-based action-ethics methodology, the intellectual assemblage must be conceived prior to the case study as an applied framework (Phase 1: Mapping). The goal is to anticipate core issues, first by thought experiments (59). Pragmatism, based on the relationship between theory and practice, focuses on courses of action and uses reflexivity to question and advance them (phase 2: framing). The outcome of pragmatism is empowerment often based on communication and/or education tools (Phase 3: Shaping).

APPLYING THE FRAMEWORK

Mapping

Deliberation is part of decision-making processes and in the *right* "location" to position ethics in governance. Mapping means here, first, acknowledging an adequate theory in ethics (see above A Pragmatic Bioethics Approach) and, second, choosing the *best* deliberative strategies to put it in practice (see below). A hybrid methodology that connects reflection, deliberation, evaluation and decision in a systemic process is detailed in **Figure 2**. However, deliberation can become a way to scale up critical reasoning at the social level if mobilized for a collective ethic, rather than to plan the technicalities of the operationalization of a project. To be systemic, such a process must "exist" as a core functioning process of a community. Although to be effective, deliberation must be constructive and useful for stakeholders. Ethnographic methods can be used to plan and design the fieldwork to ensure the deepening of deliberative reasoning (60).

This reflexive "roadmap" with several checkpoints (**Figure 2**) guided the feasibility study (2018–2021) conducted in Quebec, Canada, to evaluate the possible implementation of a monitoring system for the use of antibiotics in veterinary medicine. The deliberation process initiated in 2019 with a "Proposition" (Step 1) toward in-depth consultations and interviews to coin collaborative principles (2019–2022, Step 2), as well as the work of expertise to "engineering" a model (2019–2022, Step 3) to

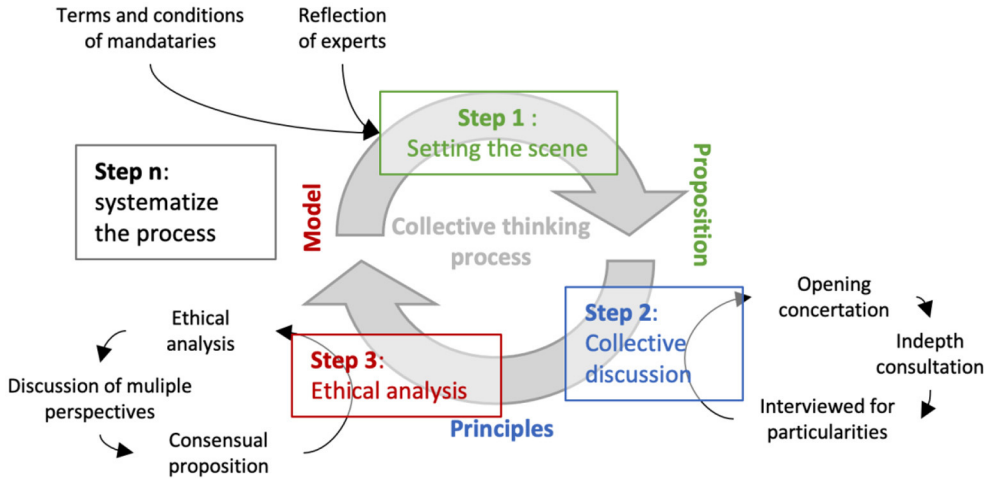

FIGURE 2 | Assembling the methods for collective thinking to orient the project of a data and information system for antimicrobial surveillance in Quebec: A decision-making process that locates ethics by default at each stage requires a *reassembling* of the program development cycle of conceptualization up to implementation and evaluation. This decision-making process becomes community-based by the bridge it creates between deliberation (Step 2) and reflexivity upstream, i.e., before and during the conceptualization phase. This "preparatory phase" becomes a process of planning (Step 1) and evaluating (Step 3) decisions in order to co-build collective ethics (for/by the community) that empowers individuals to think critically and the community to critically evaluate based on dialogue, concertation, and a proper environment for knowledge translation.

ethically negotiate at multi-scale (micro vs. macro) perspectives on conflicting discourses (61). Such roadmaps are useful for strategic and ethical leadership. The iterative process is key to building leadership in a system involving shared responsibilities between coordination (the team), several stakeholders, and policymakers. Leadership is about positioning and evolving, which means giving a clear, yet visionary, position about: Who has a job to do? To what end? and For whose interests? (34, 62, 63).

Setting the Scene

Setting the scene (**Figure 2**, Step 1) is the first step for thinking about change (64). In the case study, this stage began in 2019 with concertation that brought together 60 stakeholders[5]. The "Scene" is about setting the "vision" (65) and guidelines for *good* "preparation" (66) and "regime" (32) for managing the change. This step requires *good* coordination of expertise, resources, policies, and infrastructure, and their proper methodological assemblage with theories, concepts, and principles: we need a "global roadmap" of the case "problematization" and then possible avenues for operationalization (67).

Maps or "normative knowledge" of any kind (e.g., laws, techniques, standards, and treatments) must be designed in close collaboration with the people to whom the norms apply. Norms must be co-constructed, emerge from large social collectives, and be deliberated through an adaptive cycle of iteration. Normative thinking will lead to strategy (e.g., action plans), but must first (Step 1) build on ethical analysis. Strategic and ethical thinking must eventually hybridize into one process of reasoning through iterative deliberation and learning from feedback (Step 2).

Potter and Lisa (68) critic "sustainability" for being too strategic and not ethical enough, and highlights a way out through deliberation. Deliberation constitutes a large and every expanding methodological field of study in sociology (69), participatory research (70), management (71), governance (72), etc., that we must build on. However, as the "last step" (Step 3), ethical analysis is crucial for questioning the "terms and conditions of mandatories" over the programs or its actions before "re-proposing" (Step 1) for deliberation (6, 66).

Collective Discussion

The collective discussion consists in bridging the general with the particular (**Figure 2**, Step 2). In particular, deliberation requires a systematic intake of credible information from *the field*, such as "consultations" and "interviews" could provide, which describes the community and its understanding of the change at stake. In that sense, deliberation needs to be *data-driven*, but not exclusively, because it must also be *knowledge-driven* by a process of transfer and "translation" (14). In general, the deliberation must be based on a vision of the change, like the one depicted in the "opening concertation" (Step 1) as well as transferable information from the academic literature.

The purpose of deliberation must be about governance: its architecture and future. For example, the case study began by deliberating on the form and content of the technology (2019–2020), then on the value of its SICT program and development (2021), and (to come) on norms for responsible conduct. Governance must be evaluated and deliberate at each "start" (72). This means building a dictionary from technological terminology to ethical meaning (Step 3). These

[5]Note an ever-increasing recruitment process, involving 100 actors in 2020, to seek saturation of the perspectives, and continue the incentive process (the "interessement" according to the Latourian perspective).

last components of governance are immaterial but essential to envision a collective future (52). Meanings must be standardized (a dictionary), but also critical (reflexive governance) to learn and progress (36).

This mindset refers to system thinking (73). In practice, system thinking implies pursuing the deliberation process after the "end" of a specific mandate (iteration, Step n). The emerging vision and models provide insights for sharing the responsibilities, which means to learn and setting an *ever better future*—the scene (Step 1). For example, by laying the groundwork for a new proposal on the formal perspective of an Agreement in Principle for Responsible Animal Health Data Sharing (2021–2022). This Agreement must be initiated by design to acknowledge the "right" principle to apply for *good* collaborative governance (32) without delaying the speed of the change process (74).

Ethical Analysis

Ethical analysis, as a way to qualify the *good* and *right* "with discipline," must be at each step of decision-making processes (**Figure 2**). However, the disciplinary ethical analysis must be at the heart of governance programs (Step 3). Although ethical analysis must give the basic tone to reflexive balancing, reflexivity benefits from an abductive dialectic: to be tested by pair review, as a "discussion of multiple perspectives," and case study, as seeking for a "consensual proposition." In other words, reflexivity gains in value by the constant search for its democratization: aiming at spreading its methods, like critical thinking practices, and its result, the evaluated climate, resources, and capacities, in the case (Step 2). Moving from deliberation to the scale of a social phenomenon requires a solid reflexive "terrain," as depicted in Paquet's work on collaborative governance (75). To emerge from various stakeholders, reflexivity needs an appropriate "Habitat" to express itself, such as research hubs, living labs, innovation hubs, or business incubators, among which Observatory on the Societal Impacts of AI and Digital Technologies (OBVIA) supports the development in the Québec public-private-academic "landscape." To be inclusive, this process involved first defining problems collectively and deepening positions qualitatively (Step 2) but, therefore, an ethical analysis to progress this collective position (Step 3) considering social ethics, which "rules" may also need to be (re)set for a new "scene" in law, health, and technology (Step 1).

Ethical reflexivity is proactive in the manner of an adaptive and learning management process (76). In practice, the bioethicist's reflexivity and the team's expertise must be synchronized to scale up the (micro) personal insights to the (meso) collective, then (macro) social level (23, 42, 44). For instance, the bioethicist in this regard joins the FMVUM expert team which gives, therefore, a solid interdisciplinary ground to connect analytically with the social discourses in Québec animal health sectors. The bioethicist must shape and question the tools guiding the pragmatic negotiation toward an ethical ("pro" to "post") position, without deciding himself the sense of that "final" positioning, which must rely on an ever-evolving collective ethic (**Figure 2**, Step 2)[6]. However, the collective position must take strength in the leadership of official entities (sponsors, e.g., government), but not rely on the "belle-parole" of consensus normative principles (see the distinction between normative and appreciative knowledge in the last section). The leadership of the team in charge is based on two justifications (Step n). In the short term, this justification takes its strength from the political legitimacy, for instance, the Government of Québec's GPHP statement: through the periodic renewal of the "terms and conditions" by financial, regulatory, or declarative means. In the long term, this justification becomes powerful, however, this appreciative "parole" depicts an acceptable future having the capacity to impel a culture of empowerment (6).

Iterative Process

Ethical analyzes understood as ongoing critical thinking processes are a key functioning characteristic of reflexive governance. The ethical analysis aimed to criticize and give purpose to:

1. Strategic plans [feasibility and acceptability (78)] developed collectively to negotiate social discourses (58).
2. Decision-making processes conduct at multiple scales—the expert, the team leading the project, and representatives (e.g., sponsors, group leaders)—as they choose what best insights are meant for the community and about the future of society.

For example, One Health's scientific questioning is about how to develop a strategic (feasible vs. acceptable), judicious (risk vs. advantage), and responsible (short vs. long-term accountability) surveillance program for antimicrobial use. Conceptual roadmaps are useful to nuance and negotiate the positions of the various stakeholders (i.e., perspectives, roles, and missions) about the meaning of what is *good*, to move toward a consensual justification and thus binding decisions. The usefulness of such tools is not in their mapping of social system complexity (79, 80), but in mapping the system of values, interests, and perceptions (81, 82). A mapping of ethical frameworks and normative theories is crucial for the ongoing questioning about possible biases and finding ways to manage these appropriately when and where they arise.

When assembled with bioethical methodologies or approaches to guide the bioethicist in the use of theories in practices, deliberative *maps* (as the one depicted above) became pragmatic analytical "tools" and could support professionals or other actors in their day-to-day decision-making. These hybrid *tools* can be designed for individual or collective use. These tools focus on structuring critical reasoning to get through complicated choices; they aim to identify, nuance, and contextualize tensions that transcend the decision-maker. These tools can also be seen as evolving *roadmaps* of the One Health paradigm and an advance in applied ethics (such a tool is proposed in the last section). When applied to a case, these

[6]"Final positioning" does not exist within a collaborative governance depicted as an adaptive cycle (Step n). (Pro/post)position refers to the adaptative cycle in management (77) which must become a "constructive" and not a "disruptive" process.

roadmaps emerge from a confluence of expert and community perspectives as both have relevant viewpoints. However, roadmaps should evolve based on experience, not mere intuition. Real-world feedback is a core asset for the ongoing process of *reassembling* what is collectively conceived as a *good* change supported by intelligible methods *from the field* perspective.

Framing

Applied to the case of a feasibility study in veterinary public health, in Québec, Canada, we will see how methodological innovations are implemented by people, institutions, and theories in constant evolution: a complex that "weaves together" three dimensions of "global" existence (structural, cultural, and intellectual) that we have called "community" above (6, 15). This sociological perspective on the organization of science in society clarifies that there is no new generation of "social" but always new forms of reassembled structures, functioning, and/or purposes (16). This communitarian perspective means that much of the power is distributed in the social (of which people are the elementary unit and society is the overall organization) than what would appear to be the case under a centralized or even hierarchical understanding of authority (22). Answers to the question "how do we democratize deliberation" must find clues in "how the social "perceives" its own normative theory" in a case study: the "collective ethics."

Learnings From Sustainability

A commonly used ethical tool for bridging reflexivity and deliberation in the field of animal health and environmental risk management is to refer to the pillars of sustainable development which, by their interface, bring out a set of values as emerging fields of study: *viability*, *livability*, and *equity*. These fields act as a driving force for interdisciplinarity, notably political economy and ecology (83). However, many scholars have criticized and advanced this approach, and from which One Health should learn (52, 62, 68, 84). For example, sustainable development aims to manage—i.e., (re)maps, (re)frame, and (re)shape—based on an ongoing process of balancing the value of short vs. long-term goals (26), such as mitigating the overall risk of resistance, with its short-term goals of health care services for local communities with antimicrobial governance norms (6). The sustainable analysis could become a tool to examine feasibility studies and manage its related ethical dilemma, for instance, short vs. long-term and private vs. common considerations. Even, it could be useful if it means degrowth as not-developing pharmaceutical or reduce the use—i.e., a reframing for global acceptability as a Potterian's socio-ecological concept (**Figure 3**).

The real world is also much more complex than these three pillars and values of sustainability, because the observer evolves, learns, and "thinks [s] in systems" (73). Norton, who works on the "philosophy of sustainability," explained *good* development might be rooted instead in a "localism, experimentalism, and multiscale analysis" approach (52). Norton's understanding of sustainability allows for organizational resilience built on adaptive agility of collective policies: the adaptative management (85), allowing for several scales of observation, here the bioethicist, the FMVUM expert team, and the community as a whole (86). This learning ability is based on a functioning cycle: reflexivity, deliberation, decision, and evaluation. By reconnecting the cognitive and social spheres by introducing a multidisciplinary team at their interface called "Frontrunner," Loorbach lays the foundation for an alternative model of governance that decentralizes this four-step thinking process within the network. Frontrunner's goal is to guide the transition management, notably toward sustainability and stakeholders' empowerment, for instance, about their digital environment, responsible conduct, and norms of practice on antibiotic use. Managing here means "reassembling" the decision-making process to clarify who decides, even more, who is accountable and expected to justify; and who evaluates, that is, who provides feedback, including useful learnings to improve programs and actions (87). "Reassembling" implies a dynamic planning process well before a crisis occurs, in order to quickly involve actors with short notice to "reorganize" in (infra)structure and culture (16). To implement these new sociological models with systematized methods, we also need to use collaborative ethics (36, 88).

Learnings From Governance Systems and Community

Community-based approaches refer to collaborative and learning mechanisms: Let us propose the idea of an "adaptive co-management of transitions." Collaborative thinking is facilitated by systems of information and communication technologies (SICT) that scale data sharing to knowledge transfer, translation, and applications. The philosophy advanced in the case study was based on learning: antibiotic use surveillance supporting both national antimicrobial governance policies through public reporting and refining individual conduct through voluntary benchmarking.

Although there have been technical advances with SICT, an ongoing challenge in ethics remains to bridge the gap between experts and the community. A possible solution lies in critical deliberation and evaluation (89). Along this line of thought, Rüegg et al. (63) present an approach to collectively plan and evaluate sustainable health interventions by thinking beyond the frame to working on a strategy to support convergence and make change happen. In alignment with this perspective, Bordier et al. (90) assess the methodological and epistemological challenges behind the evaluation of knowledge emerging from "multisectoral collaboration" through "interdisciplinary insights" (91, 92). Multisectoral collaboration needs to be evaluated, notably with a focus on the performance of the surveillance process (4), on its systemic process of sharing information (91), and on the consequences of the resulting policy (36). However, one of the most challenging aspects to evaluate is certainly the value, the credibility, and the validity of One Health knowledge and policies across different domains at the time of its justification to accelerate its application (18, 23). Some answers may be found in pragmatism and how the community can learn.

To ease the functioning of SICT, one of the upstream goals must be to develop a common consensual language that puts everyone "around the table" on the same "terms" (terminological and ontological). "Language" here means helping each person or group to move beyond their position and broaden their

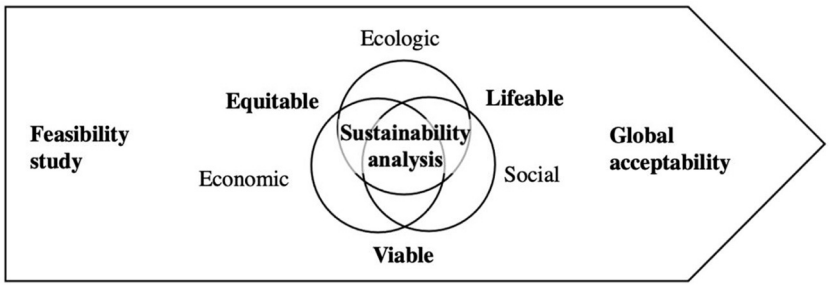

FIGURE 3 | Responsible conduct for governing sustainable technosocial development [see Potter (6)].

perspective to a collective reference point (epistemologically and teleologically). "Common" means a collective assemblage, joined under one "roof," in constant "recruitment" of social actors, diverse (axiologically) in problems, abilities, and ideas, but all interested in managing the same "problem" (14). The case study bridges the emerging collective ethics of stakeholders and the social ethics emerging of collaborative governance theories (32, 72, 75) by deliberating on an Agreement for Responsible Animal Health Data Sharing. Governance is about administrative and political structures but also goes beyond this, as a regime and vision whose rudiments must be materialized in intelligible documents accessible to all, such as an agreement, charter, declaration, code, etc.

The case study highlighted the challenge of transforming a collaborative regime (as a philosophical theory) into a governance body (administrative practices) whose functioning is acceptable for stakeholders—i.e., justified by collaborative ethics—and still meets the expectations of sponsors, mandatories, and society (34). The solution found was in iterative processes: collective ethics and governance regime must emerge from an adaptive cycle of ethical decision-making processes and from empowering leadership materializing the process in action (**Figure 2**). This new cycle (proposed for 2022) will involve the signature of that Agreement, which will "shape" the development of the data platform. To ensure the trust of stakeholders from the start to the end of the biosurveillance programs, which will evolve to expand data input across sectors and the overall outcomes of aiming to implement the One Health perspective, the Agreed Principles must progress as well (post-2023).

As Abma et al. (42) outlined, bioethicists are key assets to co-evolving practices, as "inter-ethics" (for proactive and interdependent) bridging the gap between the leadership team and the community. *Inter-ethics* opens deliberation on the (intern) program and (extern) partnership policies and values. Bioethicists are key to the functioning of large organizations such as companies, research groups, and public services. The functioning transcends (as singular) the ability to foresee a decision-maker, as the Chief executive officer (CEO), even the Chief information officer (CIO). Hermeneutic approaches, such as the maieutic process of Socratic dialogue (93), or others from applied ethics, such as casuistry (case study), should be implemented as a day-to-day approach for improving the critical thinking practice (as singular: CEO and CIO), even allowing for collective and deepen deliberative reasoning (58). The bioethicist leading these ethical approaches should not *shape* the problem in practice (94), but support the process of intellectual *mapping* and interdisciplinary *framing* (26) to help stakeholders design and manage their ethical *shaping* process (40).

The role of the bioethicist is to provide an adequate habitat for collectively "thinking global," not to prescribe global thoughts (23, 42, 44). As illustrated by John Godfrey Saxe's (1816–1887) "The Blind Men and the Elephant:"

And so these men of Indostan
Disputed loud and long,
Each in his own opinion
Exceeding stiff and strong,
Though each was partly in the right
And all were in the wrong!

The main criticism of global thinking, as here depicted in terms of communitarian approaches with the "elephant," is about the sense of urgency: Is their time for this discussion between "Indostan"? Antimicrobial use calls for rapid and radical change, yet incompatible with cultural changes requiring long-term collaborative, democratic, and reflexive processes. In the animal health sector, urgent and radical change means the commitment of stakeholders who are complexly organized as shown by Majowicz et al. (79, 80). Moreover, long-term collaborative processes mean reconciling a diverse system of deeply distinct ethical values (45), notably the views of the agri-food industry vs. vegan activists, or even traditional indigenous knowledge (34, 95, 96). The case study shows that co-building a collective ethic tends to accelerate the commitment of stakeholders by linking their actions to an awareness of the consequences, which leads them toward a culture of change. Collaborative governance, here defined as a state of mind (72, 75), even a community-based approach (97) or a communitarian paradigm (22) rather than an (administrative) governing body, accelerates this cultural bridge to the future (5). However, to be collaborative, governance must also acknowledge specific and generic concerns: sometimes even questioning collective paths in the face of local issues (bottom-up) or front of societal values (top-down). This abductive process ("local-to/from-global") necessitates the integration of top-down

(e.g., government to citizens) and bottom-up (e.g., citizen to government) modes of governance.

Learnings From Pragmatism

The case study was built on a pragmatic approach to ethics. Whereas, the *good* relies on imperatives (yes/no answers) in a deontological or legal perspective, the pragmatic ethics approach shifts the emphasis from the "imperative" to a deeper collective deliberation process that democratizes thinking about such ethical criteria as *good*, *right*, and *better*. Pragmatic ethics recommend, first of all, putting aside the prioritization of which is "right" or "wrong" between scientific, traditional, and alternative knowledge and beliefs (87). The priority is to act on tipping points, such as the need for surveillance of antibiotic use and thus for the governance of its SICT to refine practice, by seeking consensus between the parties involved on how to do it ethically (18). In practice, Callon (98) named these as points/nodes of common problematization and explained how convergent perspectives and interests stimulate the recruitment of ever-increasing numbers of actors around the common problem to solve. This is about assigning duties for what and to whom, i.e., the "pragmatic sharing of responsibilities." Moreover, responsibility is linked to resources, so deliberations must focus on the actor's duties, assumptions, and capabilities: does each stakeholder have the necessary resources, opportunities, networks, technical abilities, theories, or other necessary "tools" to achieve their goal (their responsible mission)? In the case study, all the actors involved—industry, activists, and researchers—agreed on the importance of solving the antimicrobial resistance problem, even if it was for different reasons, and to archive this collective position in an Agreement, whose principles would detail these contextualized duties. Under this pragmatic view, the core problem was no longer the "Why" to act, but the "How" to interest all stakeholders to act collectively and in concerted fashion, i.e., the "common problematization." This led us to apply ethics and its rationale to share responsibilities appropriately (e.g., duty, ability, and capacity to act) among the key stakeholders.

One of the core challenges of One Health is to operationalize pragmatic processes (the "how-s") and build consensus for action. Indeed, some deontological positions are inevitable (the "why-s") and create conflictual ethical points of view (18): Who should be responsible? Which core values to prioritize? Is it for the benefit of humans (anthropocentrism), all living beings (biocentrism), or communities (ecocentrism) that we should act? Mermet's work on social negotiation (58, 69) can help bridge the gap between *Social* and one's *thinking*. Designed for strategic analysis, social negotiation can provide pertinent tools to bring into practice Latour's framework [see Bilodeau and Potvin (99) in public health].

However, strategic analysis is a "descriptive to normative" knowledge translation process. This translation must be combined with an ethical analysis to prevent fallacies. For example, medical diagnosis (prescriptive) must be based on history and Biology (descriptive), but overall, the transition from one to the prescription of a particular treatment (an antibiotic) must be based on the clinical judgment of the physicist. The action-ethics framework presented here proposes such a "descriptive/appreciative-to-normative" knowledge translation process applied to political processes. Defining the *right* course of action, meaning the "justify normative knowledge" that will lead to responsible actions, requires the involvement of many people from various disciplines. Appreciative knowledge is the key to expanding the perspective, for example, the Government of Canada's Categorization of Antimicrobial Drugs Based on Importance in Human Medicine, which is normative, seeks to prevent harm by adding such antimicrobial governance insights to medical practice. The "inter" of the "interdisciplinary" is about quality: Who or what is bridging? Too often, the "appreciative" fields of knowledge, carried by the humanities or the human sciences, are underrepresented. Co-building collective ethics as a structuring process of a One Health transdisciplinary program will help to highlight, "in action," those missing pieces for normative practices.

An important criticism of pragmatism has to do with relativism. Who actually decides what is *right* after all? Notably about data access or even antimicrobial governance. Is it the Law, the people, the market, the activists…? In terms of relativism, these dimensions—legal, civil, financial, associative—pose "truths" of equal importance. Pragmatism in ethics does not, in any way, reject the importance of deep debates, nor the negotiation of these dimensions, or the radical questioning of the way things are done (18). Pragmatism cannot be achieved without these in-depth reflections to define broadly which *better future* we want to achieve collectively (5). Therefore, pragmatism is more about deliberation than decision, even more about education than action. However, the main characteristic of pragmatism is, indeed, action-oriented: deliberation and education process must lead to tangible, practicable, and (if well-done) prospective knowledge—such as collective vision and goal. Such an objective for discussion leads to determining agreeable points to act at a specific time and place and acknowledging a need for an ongoing process of evaluating, criticizing, and adapting those pathways of action. These enable progress for/by the community while recognizing potential harms to individuals and the environment (suffering, vulnerability, and existence). Giving credit to the community, pragmatism justifies having representatives (as an expert or social voice) capable of deepening and raising positions anchored in complicated scientific phenomena and complex system values.

To know who decides, the question should be: "Who is the most credible to carry out the collective work of deliberation?" and more importantly, "Who is responsible for it?" The case study showed that multidisciplinary teams mandated by public authorities can become key actors to structure transdisciplinary projects—a *Transprogram*—as a "flying team" in the collective creating a dynamic bridge between the expert and the whole (46). The team becomes a binding, critical, and justifying force: public values (democratic government), academic knowledge ("balanced" expertise), and a "targeted" community. A "transprogram"—a neologism that implies a "transdisciplinary" in action (56, 89)—can be conceived as a

continuous process of knowledge building and collaborative governance (16). This forces us to complexify our understanding of the "theory to practice" challenge. It is not simply a question of bringing knowledge to action through "communities of practice" or other forms of collective (100, 101). It necessitates theoreticians (e.g., philosophers and mathematicians) develop the "practitioner" reflexivity personified by *in situ* questioning of what we must do as a person and how to empower such critical thinking.

We need to organize what we—as a collective—are saying. Transdisciplinary—as the increasing relationship between sciences, technology (e.g., the industrial products), and society—introduces a confusing mess of terminologies, methodologies, and philosophies that must proceed throughout the program (as political, scientific, and societal) development. At a minimum, proceeding with this "mess" in practice requires ethics: critical thinking, codes of conduct, and responsible organizations for an ever-learning process in ethics. Extended to society, a postnormal philosophy of sciences (56) proposes new models that recognize the value of falsification (102), but extend the theory about the *Structure of Scientific Revolutions* (103) to include new tools from sociology, anthropology, and technology emerging from the digital age (74, 104). As presented in **Figure 2**, program development must return to the scale of people (theoretician, practitioner, "fieldworkers" and representatives) but be institutionalized as a democratized deliberation process. The challenges of such collaborative governance (72) and transdisciplinary research (105) are to be contextualized in a constantly changing world without losing the local perspective as developed in Morin's complexity paradigm (see the synthetic tool in the next section).

A pragmatic bioethics approach will be crucial to achieving this goal. To seek precision, the sciences tend to fall into the specialization process (disciplines and techniques) and lose the "big picture" as Saxe (106) has noted. On the other hand, philosophical reasoning, methods, and theories in ethics may lack an operational strategy for seeking and driving empirical and practical change toward empowerment and political sharing of responsibilities. Both aspects need to be integrated into an interdisciplinary process to proceed to a sustainable course of action, and this is where bioethics can step in (107), to act as a translation mechanism, and so become the missing link to materialize interdependency (37) without resorting to disciplinary reductionism (108).

Shaping

How can we seek Global acceptability? How can we mobilize science paradigms to set a "feasible" normative theory leading to a co-built code of ethics for empowering the community? (6) Shaping ethical tools, such as codes, methodologies, and education resources, are core assets for sustainability because they pave the way to basing its operation (the result of integrating the three pillars) on values (e.g., its equity, liveability, and viability): each action must be rooted in in-depth justifications

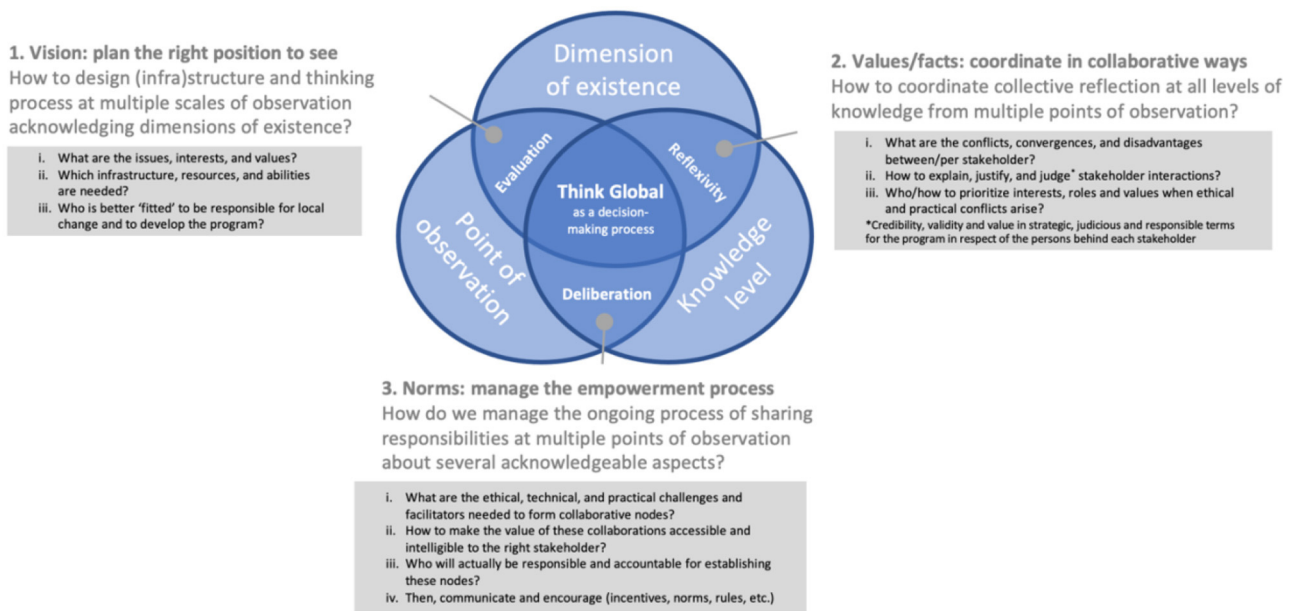

FIGURE 4 | Framework to broaden critical thinking used in the case study to building reflexive governance: A bioethical tool, "mapping" One Health methodologies and teleologies, to help in "framing" and "shaping" the work to deepen the meaning of persons, groups, and the community reasoning to broaden the collective perspective and co-build a global vision, but still locally collaborative, of One Health governance programs. Designed in empirical bioethics by case study approach, in the Quebec animal health community, the one emerging from the commonly shared One Health problematization of antibiotics (production, use, and resistance) linking Government Ministries with shared jurisdiction over animals, human, and environmental health, this tool seeks to broaden the critical thinking of the expert training in bioethics, the coordinating team members with leadership, and stakeholders. Constructed by abduction based on the revised theories and the case study depicted as a community-organization that evolved its practice. This tool must guide the reflexivity of each person at each of these collective discussion steps.

(the values) bridging sciences and ethics (5). One Health benefits from such tools, here called "bioethical" referring to this Potterian "bridge," in the format of reflexive, deliberative, and evaluative practices. The bioethical tool below contributes to deepening methodological reasoning to guide toward more practical pillars, but still rooted these in the core values of sustainability (**Figure 4**).

Broadening the vision in Saxe's poem means being more integrative, even appreciative. These *levels of knowledge* are about building consensus and deepening the reasoning of each stakeholder from their own *point of observation* to define the problem and interest in its resolution. A vision of change must transcend all *dimensions of existence* to question fallacious reasoning all along with the life of the surveillance program coming from integrating *levels* and *points* (26, 42, 44, 105).

Figure 4 proposes three practical questions at each interdependent interface—(1) evaluation, (2) reflexivity, (3) deliberation—to share responsibility and "take a position." First, "plan the right positions to see," as an *evaluator*, in terms of infrastructure and paradigm, and then "coordinate the scene and assemble collaborations from these positions" and diverse knowledge (several perspectives per level). For example, to see and coordinate, search for, or create a governance body with authority over financial planning, institutional sustainability, and stakeholder accountability (36). Collaborative governance increases credibility and trust (32), especially when the partnership that embodies this governance diversifies the collaborators. Then clarifying the *rules of the game* facilitates comanaging the empowerment process in terms of "adaptive governance systems" through deliberative processes. Taking a position means balancing knowledge from experts and value from sponsors [formal and informal terms and conditions (23)]. Note that (e)valuation is a continuous ethical-scientific process that must be pursued throughout and collectively on as many sub-dimensions as possible, and involves balancing the three identified here for a valid (pro/post)position (green) and the trans-level of knowledge (red) in time and in forms that support decision-making.

Evaluation (1) should be a continuous process, as the concept of surveillance and program evaluation understand it, but also includes the observers as a thinking unit to study the impact of the technosocial initiative and its policies. Observations should be planned upstream, based on both understanding and vision, to locate the *evaluating*-observer in an ethical and strategic place to see. Vision means a roadmap of what is foreseen as *good*, envisioning a *better future*. Maps are factual models built on-premises (values). Deliberation (3) as a social negotiation process is crucial to translate knowledge, vision, and values into policies. Deliberation implies negotiating the interests of the parts, judging actions, norms, and singular values in front of the common interests. Reflexivity (2) is the solution to an ethical, pragmatic negotiation.

The bioethical tool (**Figure 4**) integrates the three pillars to "Thinking Global" (existence, knowledge, and observation: **Table 1**) describing the intellectual world in which evaluative and deliberative decisions must be made:

1. Dimensions of existence (the empirical): the experience of life as a person and as a collective (family, society, and humanity) whose experience and context become accessible from the attentive "eye" and reflective strategies conducted in a community as a space/time, transgenerational and multispecies concept (22)—"What exists?"
2. Levels of knowledge (the cultural): sophisticated tools ranging from technologies to theories helping to deepen reasoning, to justify decision-making, or directly to change the conditions of existence—"What should it be?"
3. Points of observation (the intellectual): the intellectual lenses leading to subjective action of the expert and from the community (as thinking units, not things) to assess the effects of decisions on several patterns and scales—"What do we want to do?" "What could it be?" and "How will it be done?"

The Dimensions of Existence

The bioethical tool (**Figure 4**) extends the scientific perspectives of "experiencing" the *existence*—the observable (objective) and the being (subjective). Physics, for instance, is not only a scientific discipline but also a *dimension of existence* (15). As a knowledge, *Physics* describes the complexity of the physical world (from the Greek "physis" means nature); thus, giving physicomathematical architecture to science paradigms toward natural laws, notably in chemistry, biology, pharmacy, and also engineering, medicine, management, and any kind of evaluation techniques on antibiotics or environment (110). As a dimension, *Physical* is about space and time from which empirical phenomena emerge; thus, providing (predictive or reflexive) insights—the pharmacokinetics of antibiotics, the probabilities of resistance genes, the microbial ecology studying natural evolution, and ecotoxicological geography of heavy metals (111).

Physics, commonly referred to as objective, natural or factual understandings, is one of the fields of *descriptive knowledge,* but the "empirical" is also about the collective existence in that *physical* world, involving norms and standards. Some *normative knowledge* is based on the empirical description: when observations become physical laws through experiments or even when these laws are translated into strategies, techniques, and technologies through the lens of understandings and values, for example, a standard based on the "ecosystem services" or "footprint" communication tool (112). Although mechanical laws and probabilistic models translate the physics of the world into understandable terms and tools, it does not mean that the whole physical world is, at some point, entirely understandable or even partially controllable (the positivist fallacy), especially when it is necessary to cross dimensions (the Morin *bio-socio-anthropological model*), such as the psychology of antibiotic users and the ecology of antimicrobial components. Recognizing this fallacy, *descriptive knowledge* must not prescribe actions on its own—e.g., the statement: "This antibiotic will cure that disease"—without being understood through the lens of scientificness (e.g., validity) and as human power and will,

TABLE 1 | Reflexive aspects to think "Global" about, before and while planning and deliberating on the surveillance program[a].

	Definitions*	**Reflexive questionings****
Dimensions of existence	Empirical experience: what have we experienced as human (the subjective point of observation) and expert (the person deepening the knowledge)? **Three existing worlds globally posing complexity** 1. Biological: the physical dimension of life 2. Sociological: the institutional dimension, including laws and culture 2. Anthropological: the intellectual dimension and values (e.g., health, well-being, biodiversity)	**Localism as "To think" per community** **Sustainability**: How to strategically distribute the "observer" reflexivity and evaluation to integrate multiple dimensions of existence, to assess several organizational scales, and to judge biases and prejudices over time?
Levels of knowledge	Cultural learning: what have we learned through history (the human existence) and as communities (the overall existence above)? **Three existing thoughts posing human complexity** 1. Descriptive: understanding of the cognitive and surrounding world (to acknowledge the above dimensions of existence) 2. Normative: systematized course of action, e.g., laws, techniques 3. Appreciative: thought qualifying the past, present, and future	**Experimentalism as critical questioning** **Acceptability**: How to judiciously choose the "right" knowledge to the proper end, to integrate learning, to engage the community, and to critic decisions constructively?
Point of observation	Intellectual critics: How to criticize each other's positioning and abstract collective actions? **Three existing states of organizational complexity** 1. Networks: interactions between actors and their environment (see the actor-network theory) 2. System: a dynamic assemblage of several networks evolving according to their own principles (see the concepts of social collective or ecological community) 3. Organization: an open system with various alternative states of succession remaining stable through retroactive processes of self-determination (see the concepts of biological organism and ecosystem).	**The multi-scale analysis deliberating process** **Responsibility**: How to ethically manage program development to improve transparency in governance, arbitration of resource allocation, transition of cultural change, progression of decision-making, advancement of collaborations, and communication in the manner of a community-based, adaptive, precautionary governance process?

[a] *Referring to the Morin's paradigm of "human complexity" and "Penser Global", applied to One Health, from a synthesis of complementary theories, notably Max-Neef, Latour, and Ingold work on the translation, organization, and evolution of scientific and traditional knowledge. This synthesis is rooted in Potter's bioethical normative theory and approach for pragmatically bridging Sciences and Society to reach the goal of improving toward a better future. As any "shaped" map (technological, geological, or ecological), the landscape is in motion which requires having the case and its context under study.*

**Scientific paradigms must be used to ensure that collective ethics is shaped within the frame of sustainability (the "what is feasible by nature") to broaden our understanding of the case study (29). Built on values, the purpose of this synthesis is to broaden the vision to set ever better ethics to guide conduct, policies, and governance processes toward responsibility, i.e., the practice of empowerment ethics.*

***The synthesis was translated into questions to ease their use in situ. The purpose is to broaden the collective vision of a common change for better policies and governance processes by building a program based on core values (sustainable, acceptable, and responsible) that emerge from deeper reflections on what is "feasible." Values must apply to the ethics of science (e.g., methodology, scientificness, and accountability) to improve evaluation practices throughout deliberation and reflexivity in program implementation. This helps to justify advanced surveillance goals and processes based on a broad vision that is anchored in the paradigm of complexity (15, 109), using the precautionary principle to justify action before a causal mechanism is fully understood, such as in the case of climate change, biodiversity loss, and antimicrobial resistance.*

interwoven with belief and values, and embedded in conflicting interests and missions (45, 56, 87).

Alongside *Physics*, several other dimensions make it possible to analyze humans within their own *existence*: the *Social* and *Anthropological* dimensions of life. As for *Physics* vs. *Physical*, all those 3 dimensions are related to knowledge, among others, in psychology, ethnology, and axiology, which gives us access to its perspective. From those perspectives, we—as humans and humanity—experiment by observing and being: the dualistic (objective vs. subjective) experience of life (113). The need for both *Object* and *Subject* perspectives explains the usefulness of integrating natural, social, and human sciences. *Subjectivity*, to be understood here as *reflexivity*, brings the missing piece to positivism: the so-called postpositivism. Values, the missing piece, respond to uncertainty (56). For instance, political decisions on antimicrobial use and the progress of science in pharmacology and ecology must be proactive and responsible (the precautionary principle), despite there being no evidence (at least yet) on all the mechanisms of antimicrobial resistance, nor a full understanding of microbial evolution (1).

The challenge is to "Think global": How to integrate all these dimensions, acknowledging the pluralism of perspectives and values? Moreover, how to progress decision-making with

critical reflexivity, but without rhetorical fallacy? The answer points toward deliberation and evaluation to deepen everyone's positioning. This process must emerge from science and society (e.g., the Intergovernmental Panel on Climate Change, IPCC, or any public hearings, association, or platforms) as a community-based action-ethics methodology, although they will for this bridging process is not a given at the start.

Levels of Knowledge

Decisions are fundamentally subjective, because humans—expert and non-expert—are beings, not things, and think. Thus, some knowledge is more likely to change, while others are more stable over time (23). For example, the former refers to medical diagnostics (*appreciative*) and State laws (*normative*), while the latter refers to scientific observations (*descriptive*) such as those of physics (105). The speed of light and the gravitational constant are given (*fact*), while policies and diagnostics can change, and even less stable are the beliefs (*opinion*). These *levels of knowledge*, its strength, and even possible progression are not really *messy* but require an ongoing process of communication, management, questioning, and transparency to avoid fallacies (114). However, *normative knowledge* is a broad area. The decision leads to such knowledge: norms are about the *Act*, *Vote*, or any techniques archiving someone decision, which systematized action. For example, legal laws are *normative* as well as government, industry, and academic programs operating in the technology and, more broadly, into the *social*. Decisions—and the following actions—must always be studied, evaluated, and reframed collectively to progress these norms[7]. *Progress* is driven by examining the criteria and quality of its justifications (validity, credibility, integrity, etc.): the value of ideas and advances. These values become shared *appreciative knowledge* under community-based ethical analysis, which integrates academic, political, and civil perspectives as *Global* evaluative insights (16). The justified decision is about "responsible conduct" and "social responsibility" at the actor and network level, and should not be based on a decontextualized singular interest or ideology (5, 115). Democratizing governance processes through education and promotion refers to pragmatism or "collaborative governance," and operates through communication, open dialogues, and constructive criticism on the justificatory and uncertainty value of programs (72), but implementing large-scale evaluative, deliberative, and reflexive practices remains, indeed, a challenge. Avenues for action have been highlighted here, including the organizational dynamics emerging from an Agreement hosted by a collaborative governance body and evaluated by a Living lab.

Good decisions and norms, which means being *shaped* by ethics, require more than being *fact-driven* or *value-driven*—they need both. This requires deepening the thinking process to "transcend" all *levels of knowledge* (105), that is, to bridge the *descriptive* and *appreciative knowledge*, as the Québec Agri-Food AI Ateliers has been a successful example (46). "Transdisciplinarity" implies going beyond statistical, mathematical, or predictive data-driven reasoning to interpret data and models ethically, as appears to be *a priori* monitoring of antibiotic use and *a posteriori* the translation of surveillance insights into antimicrobial governance policies. Classical scientific methods (positivism) are valid when framed by models or conducted within controlled environments, but fail in the real world, notably the ecological (*in situ*) surveillance of antimicrobial resistance (111). This issue opens room for reflexivity and deliberation in research (as *action-research*), but also more broadly in society (as *action-ethics*), requiring educational tools to operate: the example of the antimicrobial footprint (112, 116), which integrates learnings and competencies from history and art (see Saxe's poem, above). Hard decisions about human life, environmental crises, and next-generation implications need to be "based on ethical values, which are in the long run inseparable from scientific facts" (paraphrasing Potter's maxim). This intellectual agility requires transparency to challenge justifications prior to undesirable events. Seeking transparency must be a constant and proactive quest, becoming even the core (functioning) aspect of collective ethics leading to the emergence of empowerment practice. Although conceiving *how* to manage and acknowledging *what* such transparency might be complicated to assess, deliberation points to possible paths for action.

Points of Observation

One of the main aspects to be considered goes beyond knowledge and existence and enters the area of actions. This perspective, or *point* locating the *observer* in action in the world, refers to a "bridge to the future" (5) and is about "human responsibility" (117). The positioning, as the inspector, researcher, decision-maker, or even public health policy perspective, is in constant dialectic with (influencing it and biased by) its contextualizing system (73). Indeed, "Ethical values [the positioning] cannot be separated from biological facts" (6), meaning the surrounding ecology and economy of antimicrobial resistance to the inner psychology of behaviors and will of antibiotic users and decision-makers. Ethical values are an articulation of the (free) will to change. A will for change must emerge from the case (*in situ*) through convergence with applied sciences and practices, as initiated in One Health and sustainable development. Theories remain crucial to understanding what is observed, e.g., through the anthropological (belief, family, history), the sociological (institutional power and knowledge dynamics), and the biological (e.g., organisms and organizations).

How can we manage to *Think globally* while *acting locally*, as individuals within the (social) collective, (biotic) community, even (planetary) ecosystems? How do we evaluate locally (for us) while deciding globally (for all)? How do we do planning (long-term) while implementing (short-term)? How do we regulate (decide) while questioning the norms, guidelines, and understanding that have been established? (6) These questions find some solutions under the theoretical frameworks of "thinking in systems" (73) and mathematical scales (118) as "coadaptive management" and "adaptive governance" processes (77) and under more applied frameworks such as in "transition management" (74) about governance bodies and socio-ecological systems.

[7]Economics, literally the *rules of the house* ("Okios nomos"), should join the projects in sustainable development with this general sense.

Deliberation is linked to the growing interest to find ways to integrate experts, traditional, citizens or, even alternative knowledge (71, 113). However, this should not reduce the value of scientific knowledge, but rather enrich it; these different types of knowledge (expert and non-expert) have different functions in the construction of human narratives. While expert knowledge seeks disciplines (laws, principles, mechanisms, and measures), other forms of knowledge express values, cultures, and beliefs. The latter communicates the realities of humans, beings, and things in various ways. Acknowledging the pluralism of values, as the appreciative knowledge of a collective, is a driving force (the free-will-power) for empowerment. These values can justify action before crises, i.e., to set in action the whole "scene" (**Figure 2**) to build the resilience of the system. In short, the will of a government or single decision-maker is insufficient to encapsulate the will of all (14): we need ethics (codes, methods, and prospectives) to empower each one to collective changes with a roadmap and a compass in order to navigate between different wills and aim at the common project (119). However, as an opening, this code must progress and go through an iterative phase of questioning (**Figure 1**).

CONCLUSION

This paper seeks to lay the foundations for a methodological framework in empirical bioethics. Instead of focusing on ethical theories in philosophy or sciences, we reviewed the methodological literature in empirical bioethics, One Health and Sustainable Development study to lay foundations in pragmatism (J Dewey)—(*descriptive*) pathways to operate instead of (*appreciative*) guidelines to dictate (*normative knowledge*). The ultimate goal was to support the actual will in those fields of study to build reflexive governance, notably in One Health, to address the issues concerning the pharmaceutical agents necessary for medical practice (the antibiotic cure), but modifying the environmental conditions (the problem of antibiotic resistance).

To bridge the gap between person-to-person dialogues and social negotiation processes, the operational pathway goes through comanagement techniques and must target cooperation nodes. Notably, the manager must bridge the gap between the construction of the *Social* (its ethical narrative) and *collective* practices, which leads to empowerment ethics. This operation translates the adaptive governance cycle into a new ethical technique of "R&D": Project management in *Research & Development*, the one that confines them into two parts, must shift to a more integrative practice, called here the adaptive *Reflective-Evaluative-Deliberative* cycle. These communications and knowledge systems open to a perspective bridging the biological, social, and intellectual Latourian's collective and biotic community concepts to responsibilize the former over the latter.

As shown in the case study on an antibiotic use surveillance program in animal health, being prepared means being empowered and responsible, which facilitates stakeholder engagement and even promotes collaborative nodes to accelerate changes. Preparation means joining the *community-based action-ethics* methodology to *R&D* practice from the start: at the time of policy (see: GPHP), program [see: (46)], and project (see: FMVUM team) ideation. Acknowledging ethics shows ways to share responsibilities among stakeholders to empower each in their respective competence for action. Empowerment ethics deepen the meaning of responsibility. Being responsible is more than accountability, it is linked to duty, proactive transparency, and scientificness as credibility and validity. Empowerment implies finding ways of acknowledging the respective position of stakeholders, notably roles, interests, missions, observations, and values, to respectfully manage multi-actor systems and share responsibility toward successful and ethical changes.

The ethical conflicts between the cognitive and the collective—as the singular will and common good—can only be managed through an open dialogue that continuously seeks *ever better* solutions, as more accuracy and consensuality. Thus, instead of questioning how to access data as a justified end[8] to solve the antibiotic resistance problem or other One Health problems, we should look to empower the community to manage their data (a fairness *Open data* approach per community). The question we should be asking, then, is: How should we manage an *Open dialogue* between data *producers* and *users* within the community to start local changes? With empowerment ethics focusing on transparency, translation, negotiation, and arbitration, what we should call *reflexive governance*, we can engage groups and collectively drive cultural change and the willingness to accelerate it (an *Openness to data*), and then connect communities (human, animal, and ecosystem health) to reach the broader perspective of One Health and the Sustainable development of its programs, even its paradigm.

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

AB was responsible for the conception and ideas presented in this article, contributed to the planning, and conduct of the qualitative survey described in the article as a case study. CA and BW-J reviewed the initial manuscript, contributed to the text through changes to structure and addition of new content, and approved the final manuscript. All authors contributed to the article and approved the submitted version.

[8]For example, are the FAIR Guiding Principles a means or an end? (120). As a means, they respond to the criticisms leveled at the *Open Data movement*, when perceived as seeking "open bars." We need the complement of a FAIRness ethic to frame responsible data sharing.

FUNDING

This article was supported by funding (Ph.D. scholarships) from the Institut de Valorisation des DOnnées (IVADO), the Global One Health Network (G1HN), Centre de Recherche en Santé Public (CReSP) and the International Observatory on the Societal Impacts of AI and Digital Technologies (OBVIA). The corresponding author was an employee of the Faculté de Médecine Vétériaire at the Université de Montréal, hired to accompany the feasibility study on the implementation of a monitoring system for antibiotic use in veterinary medicine in Quebec by the Center for Expertise and Clinical Research in Animal Health and Welfare (CERCL) mandated by the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ).

ACKNOWLEDGMENTS

The authors recognize the important contributions of the team leading the feasibility study of monitoring antibiotic use, and all those who participated in this collective brainstorming process, especially Ferrouillet, Laroche, and DesCôteaux, in organizing the deliberations, and the Government of Québec Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ). Affiliated with Groupe de Recherche en Épidémiologie des Zoonoses et Santé Publique (GREZOSP), Centre de Recherche en Santé Publique (CReSP) and Observatoire Internationale sur les Impacts Sociétaux de l'IA et du Numérique (OBVIA), the author was able to benefit from rich discussions with members of these communities who contributed to the reflections presented here.

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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.

frontiers in Public Health

BRIEF RESEARCH REPORT
published: 24 March 2022
doi: 10.3389/fpubh.2022.853862

A Comprehensive Tobacco Control Policy Program in a Mining Industry in Indonesia: Did It Work?

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OPEN ACCESS

Edited by:
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Bielefeld University, Germany

Reviewed by:
Doris Ilse Silvia Bardehle,
Foundation of Men's Health, Germany
Madhumita Dobe,
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Specialty section:
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

Received: *13 January 2022*
Accepted: *21 February 2022*
Published: *24 March 2022*

Citation:
Prabandari YS, Bintoro BS and Purwanta P (2022) A Comprehensive Tobacco Control Policy Program in a Mining Industry in Indonesia: Did It Work? Front. Public Health 10:853862. doi: 10.3389/fpubh.2022.853862

Background: Risk factor controls, including smoking cessation and prevention, impact health costs. This study aimed to describe the Kaltim Prima Coal (KPC), one of Indonesia's largest coal mining operations, comprehensive tobacco control policy program in 2015 and its impact on smoking behavior among the employees.

Method: A survey among 404 employees was conducted to assess the impact of the smoke-free KPC programs. In addition to the descriptive analysis, logistic regression was used to measure the association of intention to the smoking behavior change and the association between intention and the determinants using the Theory of Planned Behavior in 102 smokers.

Results: A series of tobacco control programs: advocacy, health education, brief interventions for smoking cessation, peer counselor training, media campaigns, and policy regulations were implemented. About 95.5% of the respondents attended the KPC Smoke-Free 2015 programs, and 97.8% reported they already knew that KPC is a total smoke-free area. Nearly 50% of the respondents expressed that the staff complied with the rules and no longer smoked in KPC. Majority of smokers (76.6%) reduced their consumption, and 5.6% of them quit smoking. Among smokers, we found that attitude toward smoking cessation, subjective norm, and perceived control for quitting were related to the intention to stop smoking.

Conclusions: The KPC smoke-free policy has been comprehensively implemented. Regulations on smoking and tobacco controls should be maintained, and monitoring should be consistently done. Media campaigns on the regulations and the availability of trained peer educators for smoking cessation help need to be applied continuously.

Keywords: smoke-free policy, worksite, mining, Indonesia, Kaltim Prima Coal

INTRODUCTION

Background

Indonesia is one of the most populous smoker countries in the world. The Basic Health Research in Indonesia reported that the prevalence of smokers aged >10 in 2018 is 28.9%, and 55.8% of males are smokers (1). The number of men smokers is among the highest globally (2). The average number of cigarettes consumed in Indonesia is 12.8 cigarettes/day (the equivalent of one pack of commonly-sold cigarettes in Indonesia) (1). In 2017, there were 2,25,720 deaths caused by tobacco in Indonesia, while 1,47,510 were due to tobacco-related cardiovascular disease (CVD) (3).

Tobacco is considered the second most common risk factor for death and disability and a contributing factor for the three leading causes of death in Indonesia, which are stroke, ischemic heart disease, and diabetes (4). Smoking has been proven to be harmful to health, causing lung problems such as emphysema, CVD, heart attacks, leading to premature death (5, 6). Smoking also worsens sperm quality for men, contributing to infertility problems (7).

The discussion about smoking has been expanding to concerns about secondhand smoke (SHS) exposure since 50 years ago. The debate started in 1972, but the conclusion is still the same: exposure to SHS or Environment Tobacco Smoke (ETS) is harmful (5, 8). A significantly increased risk of severe dementia syndromes was reported among people exposed to ETS (9). People exposed to ETS at their workplace were reported 37% more likely to have visited a doctor for a respiratory illness (10). Several studies showed no risk-free level of exposure to SHS (5, 8). Almost 75% of adults aged >15 years old in Indonesia were exposed to ETS (11). About 20% of non-smoker adult workers were exposed to SHS in the workplace (12). Exposure to SHS is a cause of many illnesses. Homes and workplaces are where the most exposure to SHS occurs. Complete elimination of tobacco smoke protects non-smokers from exposure to SHS (13), while partial bans on smoking cannot eliminate exposures of non-smokers to SHS (8). Meanwhile, one study found that implementing the smoke-free law in Thailand decreased acute myocardial infarction hospitalization by 13% among adults < 45 years old (14).

Existing findings from recent studies indicate that smoke-free legislations provide benefits in many ways (15–17), i.e., reducing SHS, less smoking prevalence, and cessation (18). Implementing a full restriction policy is the only effective way to ensure that SHS exposure prevention is successfully implemented in the workplace (8, 19). Economically, smoking-related costs can be reduced by establishing smoke-free workplaces (20).

Smoking cessation programs can be part of the smoke-free workplace as a complement to support employees to comply with the zero-tolerance of tobacco policy (21). A review of the systematic review of smoking cessation in the workplace indicated that several interventions combined (six trials; 5,018 participants) helped people to stop smoking (22). Smoke-free workplaces have been indicated to encourage employees to stop smoking; however, the mechanism of behavior change is not well-understood. A theoretical framework such as the theory of planned behavior (TPB) can be applied to evaluate a smoking intervention (23), as reported by Ajzen that the TPB has been widely used in health research and cited more than 4,000 times by google scholar in 2010 (24). The TPB consists of three main constructs: attitude toward behavior, subjective norm, and perceived control, which contribute to intention to perform the behavior (25). Where attitudes and subjective norms are favorable and perceived control is high, a strong intention to perform the behavior should occur. The behavior will be formed as a result of strong intention. Fong et al. (26) used the TPB as one of the primary theories underlying the impact of countries' level of tobacco control policy on smoking behavior. Moreover, Macy et al. (27) used structural equation modeling to conduct a theory of planned behavior analysis with data from 395 smokers living in seven Texas cities, three with a comprehensive smoke-free air law and four without a comprehensive law. The result showed that smoke-free air laws appear to influence quitting intentions by forming positive attitudes about regulating smoking in public places and the perception of normative pressure to take measures to quit. This paper is sought to assess the impact of a comprehensive tobacco policy program in a big mining company on smoking behavior and analyze the determinant factors related to the change of smoking behavior based on the theory of planned behavior.

Setting and Intervention

PT Kaltim Prima Coal (KPC) is located in East Kalimantan. Starting its exploration in 1982, KPC currently employs 25,363 people (4,947 of PT KPC and 20,416 from contractors). Smoking prevalence among employees of KPC reached 49% in 2010 and only fell very slightly to 46% in 2013. Before the Governor of East Kalimantan Regulation on Smoke-Free Areas was enacted in 2010, KPC had already started implementing a smoke-free zone. The implementation was made after three employees died within 2 months due to smoking-related diseases.

In January 2014, KPC management launched a comprehensive smoke-free policy, including the quit smoking program named "Smoke-Free KPC 2015" (*KPC Bebas Rokok 2015*). KPC has applied several rules and regulations to accelerate that program, such as random proactive inspections of workers to check whether workers are still carrying cigarettes into the working site. KPC has also conducted health education for employees started from high management up to the laborers and the employees' wife association and community surrounding the mining. Outdoor media and videos were also applied as health education messages. There is a feedback system between this smoke-free program and its environment for evaluation purposes, and fidelity assessments need to be routinely conducted to determine its effectiveness (28). Twenty employees were trained as peer counselors for smoking cessation in the education and outreach programs.

MATERIALS AND METHODS

This cross-sectional study used a self-reported questionnaire as the data collection tool. The population of this study was KPC workers, and the participants were 404 workers. Knowing

that KPC consists of several divisions, stratification sampling was done using data from the human resource department of KPC. Ethical approval was obtained from the Faculty of Medicine's Medical and Health Research Ethics Committee, Universitas Gadjah Mada. All of the participants completed a written informed consent form regarding the goals of the study and the willingness to participate in the study. Variables asked to the smoker participants concerned about their smoking habit and cigarette consumption change, while knowledge and attitudes on smoke-free policy variables were obtained from all participants. Questions for smoking habits were: "How often did you smoke a cigarette this month?" and "How many sticks do you smoke per day?". Smokers' smoking behavior change was measured by the tobacco consumption change in general and during their working time inside KPC. The options of those questions were "no change," "increase," "decrease," or "stop smoking." Knowledge (awareness) of the smoke-free policy was based on questions with options of "yes" and "no." We also asked the respondents' views on policy implementation of KPC' SFA Regulation in a five-scale Likert scale.

In addition to descriptive analysis, we developed a model using the Theory of Planned Behavior to measure the association of intention (no intention to stop and intended to stop) to the smoking behavior change ("no change and increase" and "decrease or stop smoking."). We also measured the association between intention and the determinants, namely knowledge (total score of knowledge of the smoke-free policy, 0–3), attitude (total score of respondents' views on policy implementation of KPC' SFA Regulation, 0–8), subjective norm (total score of respondents' views on the support of family on the smoking cessation, the intention of smoking cessation because of family, and KPC policy supporting them to stop smoking; 0–3), and perceived behavioral control (total score of respondents' views on the benefit of the smoking cessation, the statement on the duration of having smoking cessation intention, self-confidence on stop smoking; 0–3). Cronbach's alpha was used to examine the reliability of all instrument constructs. The Cronbach's alpha value for the scale of knowledge ($\alpha = 0.7$), attitude ($\alpha = 0.7$), subjective norm ($\alpha = 0.8$), and perceived behavioral control ($\alpha = 0.6$) were considered acceptable and good internal consistency. We used logistic regression to measure the association of intention to the smoking behavior change and the association between intention and the determinants. Data were analyzed by Stata Statistical Software Release 12 licensed to the Department of Public Health, Faculty of Medicine, Universitas Gadjah Mada.

RESULTS

The Smoking Cessation Program Titled "Smoke-Free KPC 2015"

KPC started executing a massive smoking cessation multi-component program at the beginning of 2014 to achieve a smoke-free worksite in January 2015. More than 1,000 people participated in various activities, including advocacy, health education, training, small group discussion, and a seminar. Health education was applied to all levels, from top management to field workers, using various events. More than 200 managers, supervisors, and superintendents attended the main meeting to launch the multi-component smoking cessation program. KPC also implemented health education for staff's families, mainly for workers' wives, students in schools surrounding KPC, and the community in Sangatta, a small district in East Kalimantan where KPC is located. More than 300 participants consisting of school teachers and principals, mining contractors, government officials, and community representatives attended a 1-day seminar proposed to the local government to make Sangata healthy. The resource persons of the seminar consisted of tobacco control experts from the well-respected Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada in Yogyakarta, Indonesia, and the CEO of KPC. The highlight of the sharing session was testimony from one staff of KPC who used to be a smoker and quit smoking due to having suffered from a heart attack.

The Health Safety Environment and Security Division conducted advocacy to the top management to support and reinforce the smoke-free policy. To show the effect of smoking, they also downloaded several short videos and televised them on the bus that takes mining workers to the worksite every day. In addition, twenty ex-smokers were trained in a 2-day training as peer educators to help the employee smokers quit. Based on the discussion with the peer educators 6 months after the training, only a very limited number of smokers consulted with them. However, they tried to talk about quitting smoking with their smoker colleagues in every available chance.

The Smoke-Free KPC 2015 policy has been applied with close monitoring. KPC even applied random screening of bringing cigarettes and matches amongst employees. Supervisors often remind their workers about not smoking and the importance of quitting smoking. Management has also reminded employees about the smoke-free area policy in every meeting.

Big billboards about Smoke-Free KPC 2015 have been placed in several strategic locations in the mining area. Posters were put up in the KPC clinic, dormitory, and canteen. Leaflets were also given to the attendees of health education sessions and made ready to be given to all patients who visited the KPC clinic.

The Evaluation Survey

A total of 404 workers participated in the evaluation survey conducted in 2016; only 363 could be analyzed (**Table 1**). The majority of the respondents were male (89.8%), married (87.3%), and lived with family (80.7%). The proportion of smokers was 28% of the KPC workforce.

Knowledge of smoke-free legislation at the provincial and company level is presented in **Table 2**. Almost all of the participants attended the company education and socialization campaigns. There was no difference in the knowledge between the type of smokers. Only half of the participants reported that they knew the new smoking laws were enacted by the Governor of East Kalimantan. Higher proportions of workers (more than 90%) said they have been aware that KPC is a 100% smoke-free area.

Respondents" views on policy implementation of KPC" SFA Regulation are presented in **Table 3**. Almost all non-smokers and

89% of quitters perceived that workers should not be allowed to smoke in the workplace, compared to only two-thirds of the smoker ($p < 0.001$). The majority of the non-smokers (93.2%) and quitters (82%) also believe that KPC's SFA regulation should have been enacted earlier. No significant difference was observed in the perceptions that staff members have understood the KPC" SFA regulation (non-smoker 83.2%, quitter 78%, smoker 73.5%; $p = 0.162$) and have implemented the KPC" SFA regulation (non-smoker 54.7%, quitter 50%, smoker 49%; $p = 0.615$). While 96.3% of non-smokers and 95.0 of quitters agreed or strongly agreed that everyone in KPC was supposed to obey the KPC SFA regulation, only 82.4% of the smokers expressed their agreement ($p < 0.001$). Concerning having smoking areas in the workplace, about a third of non-smokers (29.8%) and quitters (36%) agree with the statement compared to 71.6% of smokers ($p < 0.001$). The proportion of smokers who agreed that any place in KPC, including the outdoor area, was supposed to be SFA was less (58.8%) than their counterparts (non-smoker 86%, quitters 77%; $p < 0.001$).

Approximately 10 months after the KPC smoke-free regulation implementation, 78.4% of smokers reduced their consumption, and 4.9% of all smokers stated that they had already quit smoking (**Table 4**). While only half of the smokers reported that they still smoke in KPC (54.9%), the majority of them still smoke outside KPC (91.2%), in homes (88.2%), and public (81.4%). In the model using the Theory of Planned Behavior, we found that knowledge (OR 1.3; 95%, CI 0.8–2.1), attitude (OR 1.9; 95%, CI 1.3–2.9), subjective norm (OR 4.3; 95%, CI 2.1–8.9) and perceived behavioral control (OR 2.7; 95%, CI 1.5–4.6) were positively associated with the intention to stop smoking (**Table 5**). The intention to stop smoking was also positively associated with decreasing smoking behavior or smoking cessation (OR 3.2; 95%, CI 1.1–9.3).

TABLE 1 | Respondents' characteristics ($n = 363$).

Variables	*n*	%
Sex		
Male	326	89.8
Female	37	10.2
Age (mean SD)	36.7	8.3
Marital status		
Unmarried and widowed	46	12.67
Married	317	87.33
Living		
Family	293	80.7
Alone/dorm	70	19.3
Smoking status		
Non-smoker	161	44.4
Quitter	100	27.6
Smoker	102	28.0

SD, standard deviation.

DISCUSSION

This evaluation was conducted 10 months after strengthening KPC Smoke-Free 2015, the same period between implementation and the evaluation study by Fichtenberg and Glantz (post 10 months) (29). A smoke-free workplace is a cost-effective, public health approach that encourages the important long-term goals of eliminating tobacco use and SHS exposure. Following KPC implementing the smoke-free legislation, which began in 2010, an evaluation in 2014 revealed smoking behaviors were reduced slightly from 49 to 46%. This more recent study revealed that the smoking rates have dropped to 28%. This substantial decrease is significantly higher compared to other studies (mean 3.8%; 95%, CI: 2.8–4.7%) (29). Fichtenberg and Glantz, who reviewed tobacco control policy, reported that 100% of smoke-free policies decreased smoking prevalence by about 3.8% and reduced consumption by three cigarettes every day (29). The combination of prevalence decreasing effect and reducing the number of cigarettes smoked every day resulted in an average decrease of 1.3 cigarettes per day per staff, equivalent to the relative decrease to 29%.

This difference in smoking prevalence in KPC between 2014 and this study might be due to several reasons. Smoking rates decline significantly in a total ban area, while a partial smoking ban has no significant impact (30). Workplaces that implement complete smoke-free regulations produce twice the effect on consumption and prevalence as policies that still allow smoking in some areas (29). KPC implemented a total ban and applied other tobacco control activities, and closely monitored

TABLE 2 | Knowledge about smoke-free policy.

			Non-smoker	Quitter	Smoker	Total	*p*-value
Ever had company socialization	Yes	*N*	153	98	96	347	0.396
		%*	95.0	98.0	94.1	95.6	
Knowledge of Provincial SFA regulation	Yes	*N*	76	50	50	176	0.901
		%*	47.2	50	49.0	47.5	
Knowledge of workplace is SFA by Provincial SFA regulation	Yes	*N*	81	51	52	184	0.992
		%*	50.3	51.0	51.0	50.7	
Knowledge if KPC is SFA by company regulation	Yes	*N*	160	97	101	358	0.231
		%*	99.4	97.0	99.0	98.65	

**Percentages represent those participants who answered "yes".*

TABLE 3 | Respondents'ts' views on policy implementation KPC' SFA Regulation – percentage agreement for non-smokers and smokers, % Agreement (Strongly Agree/Agree), by smoking status ($n = 363$).

		Non-smoker	Quitter	Smoker	*p*-value
The workers shouldn't be allowed to smoke in the working place.	*n*	155	89	68	<0.001
	%	96.3	89.0	66.7	
KPC' SFA regulation should be enacted earlier	*n*	150	82	69	<0.001
	%	93.2	82.0	67.7	
Staff have understood the KPC' SFA regulation	*n*	134	78	75	0.162
	%	83.2	78.0	73.5	
Staff have implemented the KPC' SFA regulation	*n*	88	50	50	0.615
	%	54.7	50.0	49.0	
Everyone in KPC supposed to obey the KPC' SFA regulation	*n*	155	95	84	<0.001
	%	96.3	95.0	82.4	
Only KPC staff supposed to obey the KPC' SFA regulation	*n*	129	84	83	0.734
	%	80.12	84.0	81.4	
The workplace should provide a smoking area	*n*	48	36	73	<0.001
	%	29.8	36.0	71.6	
Any place in KPC, including the outdoor area, supposed to be SFA	*n*	139	77	60	<0.001
	%	86.3	77.0	58.8	

p-value from Chi-square or Fisher exact test.

TABLE 4 | Place of smoking, smoking cessation related component (among smokers, $n = 102$).

	n	%
Smoking behavior change		
Ever stop	5	4.90
Less	80	78.43
Stay same	16	15.69
More (increased)	1	0.98
Place of smoking[a]		
KPC	56	54.90
Outside KPC	93	91.18
Home	90	88.24
Public	83	81.37

[a]*Proportion of respondents answering: always, often, sometimes, and seldom to smoke in the given places.*

TABLE 5 | The construct of theory of planned behavior in the intention to stop smoking and smoking behavior change (among smokers, $n = 102$).

	OR	95% CI	*p*-value
Construct on the intention to stop smoking			
Knowledge	1.3	0.8–2.1	0.206
Attitude	2.3	1.5–3.8	<0.001
Subjective norm	4.3	2.1–8.9	<0.001
Perceived behavioral control	2.7	1.5–4.6	<0.001
Construct on the decrease and stop smoking behavior change			
Intention to stop smoking	3.2	1.1–9.3	0.032

OR, odds ratio.

the policy implementation. Random proactive inspections to prevent workers from bringing cigarettes to the working site were done. Close monitoring of smoking behavior and law enforcement on smoke-free regulations are considered effective (31, 32). Some interventions directed toward individuals include individual peer counseling and education for all stakeholders. Multiple approaches directed toward individual smokers increase the likelihood of quitting smoking (22, 33). A series of health education promotions have also been done among stakeholders and a media campaign all over the company areas. Health education via media has been shown to reduce smoking prevalence (34). Sims et al. in 2014 indicated that tobacco control advertisements on television could reduce smoking proportions in England by 13.5% (35). Furthermore, KPC has held training for ex-smoker staff to become peer educators for smoking cessation counseling. A study showed that peer education was appropriate and considered effective (22), supporting the importance of this effort.

The reduction in smoking occurred because the smoke-free legislation increases support for regulating smoking, reduces the social acceptability of smoking, limits opportunities for smoking, and leads to less socially cued smoking (36). In the U.S., smoke-free regulations and ordinances also reduce non-smokers' exposure to SHS and decrease respiratory symptoms related to exposure (37). In addition, these laws result in decreases in smoking prevalence and total cigarettes consumed by smokers while increasing cessation attempts. A study in California found a dose-response relationship that associated higher smoking cessation rates with more comprehensive laws (38). A study in France also reported that smoke-free regulations decreased

smoking prevalence (39). From the findings in recent research, current smokers have less productivity which averaged a 4.5% decrease (40). Thus, quitting smoking also benefits the company directly by ensuring productivity.

Effective implementation of smoke-free regulations is still challenging in developing countries, such as Nigeria (41) and Bangladesh (42). Moreover, Indonesia is placed as the fourth most populous smoker country globally and the seventh highest in cigarette production (43), while the tobacco control policy remained in its infancy, particularly before 1990 (44). Although an Indonesian delegation participated in developing the Framework Convention on Tobacco Control (FCTC), Indonesia is the only country in the Asia Pacific region that has not ratified the FCTC. Up to April 2013, FCTC has been signed by 173 countries (43). While Indonesia has not signed the FCTC, in 1999, the government issued Regulation of Indonesia number 81, and it was aimed to regulate smoke-free areas in seven settings, including the workplace. The regulation was renewed in 2003 and expanded in 2009 with Government Regulation number 36. That regulation should be followed with local regulations. In 2013, the Ministry of Health of Indonesia reported that ten provinces out of 33 and 127 districts or cities out of more than 500 had issued local regulations on smoke-free areas, and workplace or smoke-free worksite areas should be included in those local regulations (45).

Awareness of smoke-free legislation remains the key to successful implementation (46, 47). The combination of awareness campaigns, legislation, enforcement, and price policies successfully led Finland to implement smoke-free workplaces making a significant tobacco consumption decline (48). Excellent awareness of smoke-free company regulations should be equally followed by awareness on the provincial level because the laws should be applied to everyone (49). In this study survey, the awareness of KPC staff of the company regulations was good, and nearly 100% knew the regulations. A study in Kyrgyzstan among mining employees reported that only 63% (49% women) were aware of tobacco control laws (50). However, only half of the participants were aware of local government regulations. Awareness differences between the provincial and company level policy might be due to the different scope of promotional dissemination. Reduction in smoking behavior inside the company might be followed by smoking in a restricted area outside the company because employees lack knowledge concerning new regulations by the government concerning smoke-free areas in public places.

The findings on the smoking behavior inside the company should also be directly addressed. KPC needs to consider eliminating the possible areas which the staff use to smoke and place extra smoke-free campaign material there (51). Adherence to the smoke-free company regulations should be monitored because other regulations and violations should be addressed continuously with the counseling process (52).

Behavioral changes that occurred after the intervention in this study were further analyzed based on the TPB theory, and the results showed that the behavioral changes that occurred were related to the intention to quit. Meanwhile, attitude, subjective norm, and perceived control have a relationship with intention. This result is in line with the systematic study conducted by Lareyre et al. (23), which shows that the TPB-based interventions have an impact on intentions, attitudes, subjective norms, and perceived behavioral control by 42–50%. A previous study also reported that behavior change interventions based on theory have more promise than interventions without theory (53).

This study has some limitations since this was a cross-sectional study and did not use a randomized controlled trial or a quasi-experimental design. The sample of previous prevalence studies also included all the workers and staff, while this evaluation used a multi-stratification sample.

The cause and effect of the comprehensive tobacco control program cannot be definitively established. The company implemented the comprehensive intervention and cannot be evaluated separately. This study more focussed on the impact of the overall intervention. In addition, the behavior change has been analyzed using the TPB, although the scale for asking the TPB constructs used limited questions taken from the original questionnaire. Further comprehensive questions are needed to assess the variables related to the TPB. Further study is recommended to assess the effectiveness of the intervention. Moreover, this study was conducted in a mining company in East Kalimantan, which may not represent all companies in Indonesia. Therefore, the generalizability of this study is limited. However, even with these limitations, this study is aimed to contribute toward tobacco control programs in Indonesia, particularly in worksite settings, where there is an obvious need for education and socialization programs promoting smoke-free workplaces.

CONCLUSIONS

This study reveals that comprehensive smoke-free regulation impacts awareness and reduces smokers in the mining industry. The findings support tobacco control activities that remain not strongly implemented in Indonesia. Smoke-free workplaces and other settings should be implemented intensively and widely to strengthen tobacco control policies. Therefore, there is a need to advocate for the central and local governments to apply the smoke-free policy.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors upon request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Faculty of Medicine's Medical and Health Research Ethics Committee, Universitas Gadjah Mada. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

YP was responsible for study design, data collection, statistical analysis, and article writing. PP participated in the study design

and data collection. BB contributed to the study design article writing and was responsible for the statistical analysis. All authors contributed to the article and approved the submitted version.

FUNDING

This work was supported by research grants from the *Dana Masyarakat* (Citizen Fund) Platform from the Ministry of Higher Education and Research, Indonesia. The study's sponsor had no role in study design, data analysis, data interpretation, or report writing. The opinions expressed in this report are not necessarily those of the funders.

ACKNOWLEDGMENTS

The authors thank the participants and all involved in the surveys, including the nursing students of FM PHN UGM, especially Istriyani, Pratiwi, Rismala, and Ramadhani. The authors would also thank Wardono and Aspita from KPC for their contribution to the data collection.

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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.

frontiers | Frontiers in Public Health

ORIGINAL RESEARCH
published: 01 June 2022
doi: 10.3389/fpubh.2022.873845

Data Mining Approach: What Determines the Wellbeing of Women in Montenegro, North Macedonia, and Serbia?

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Background: Women's happiness and life satisfaction, often summarized as subjective wellbeing, are of great value for most individuals and are associated with various determinants. The countries of the Western Balkan are of particular interest after the political changes in the nineties. Are the women satisfied with their lives today?

Methods: We use the most recent datasets of the Multiple Indicator Cluster Surveys (MICS) for women 15–49 years old and with comparable data coverage for three countries of the Western Balkan belonging to the former Yugoslavia, namely Montenegro, North Macedonia, and Serbia. After sorting out variables of limited relevance or quality (missing values >50%), the remaining 32 variables followed a descriptive analysis. Four potential determinants of subjective wellbeing (SWB), an integration of happiness and satisfaction with life, entered an interactive Classification and Regression Tree (iC&RT) to account for their mostly bivariate format: age, education, region, and wealth.

Results: The iC&RT analysis determines the influence of 4 independent variables (age, education, region, and wealth) on overall happiness, satisfaction with life, and subjective wellbeing, resulting in a high overall SWB of 88.9% for Montenegro, 82.1% for North Macedonia, and 83% for Serbia. The high relevance of younger age, higher education, and wealth, as critical determinants of a high SWB, and the lesser role of regions except for Serbia is confirmed. The spread of SWB in defined population subgroups ranges from 80.5–92.6% for Montenegro, 64.2–86.8% for North Macedonia, and 75.8–87.4% for Serbia.

Conclusions: The three selected South-Eastern European countries of the former Yugoslavia (Montenegro, North Macedonia, Serbia) represent high levels of subjective wellbeing of women and a narrow range between the lowest and highest population groups. Women in Montenegro take a top position regarding their subjective wellbeing.

Keywords: happiness, life satisfaction, subjective wellbeing, MICS, Montenegro, North Macedonia, Serbia, women

OPEN ACCESS

Edited by:
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Reviewed by:
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Silvia Gabriela Scintee, National School of Public Health, Management and Professional Development, Romania

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Specialty section:
This article was submitted to Environmental health and Exposome, a section of the journal Frontiers in Public Health

Received: *11 February 2022*
Accepted: *19 April 2022*
Published: *01 June 2022*

Citation:
Bjegovic-Mikanovic V, Wenzel H and Laaser U (2022) Data Mining Approach: What Determines the Wellbeing of Women in Montenegro, North Macedonia, and Serbia? Front. Public Health 10:873845. doi: 10.3389/fpubh.2022.873845

INTRODUCTION

Personal happiness and life satisfaction are two terms of great value for most individuals. Still, they are difficult to define precisely. They stand for emotions and perceptions of life, which may refer to different circumstances and the impression upon a personality due to their upbringing, experience in life, and beliefs (1, 2). For these reasons, the scientific literature increased only recently (3), but

still lacks uniformly accepted and precise definitions of what is meant (4). Nevertheless, modern science allows for the first time to quantify happiness, a subject of moral philosophies debated since Aristotle (5).

In the literature, various additional terms are discussed, the foremost is wellbeing, often divided into three subdomains capturing the experience of positive feelings (hedonic wellbeing corresponding to happiness), levels of satisfaction with life (evaluative wellbeing), and a sense of purpose and meaning (eudemonic wellbeing) (6). As indicated by several authors (7–9), subjective wellbeing (SWB) is a result of two primary factors: happiness and satisfaction with life, both with an impact on resilience (10). Many of the discussed determinants of SWB can be considered in the context of national or regional culture, defined by UNESCO (11) as "…the set of distinctive spiritual, material, intellectual and emotional features of society or a social group, and that it encompasses, in addition to art and literature, lifestyles, ways of living together, value systems, traditions, and beliefs." Other studies confirm social cohesion and social capital as supportive of happiness [e.g., (12)]. The specific connection to education is discussed by Saevi (13), who describes the North American model as "psychological and managerial motivation oriented toward educational success," whereas the "European pedagogy …had stronger structures of a rather contradictory human existential reflection."

Evidence about the relationship between age and wellbeing is mixed. In the Western world, the connection is best explained by a U-shaped curve, the lowest levels of wellbeing in the middle age groups. Latin America shows a similar pattern, whereas, in sub-Saharan Africa, we see only minor changes over time (6). Respondents from the former Soviet Union and Eastern Europe, on the other hand, show a sizeable progressive decline in wellbeing with age [see also (14, 15)].

Gender usually is found to be a significant predictor of wellbeing. However, there is mixed evidence as to which gender experiences higher wellbeing. Combined multivariate analysis of the 2009 and 2011 *Scottish Health Survey* data indicated that men had higher odds than women for positive wellbeing. An analysis of the Annual Population Survey 2011-2012 data found that women had a higher overall wellbeing (16). Moreover, it has been reported that hedonic wellbeing was higher in men and eudemonic wellbeing higher in women (17, 18). Regarding gender issues, the Longitudinal Study of Young People in England interviewed a cohort of respondents annually from 2004 (then at age 13) until 2010. Data from 2010 indicated that at age 19, young people who identified as heterosexual "were more likely to be satisfied with their life" than those who identified as homosexual or bisexual (19).

Furthermore, a mutual influence between the dimensions of happiness and health has been confirmed repeatedly (3, 6, 17). In the prospective United Kingdom Million Women Study (20), happiness did not relate to mortality, while Kim et al. (21) and Trudel-Fitzgerald (22) report associations with cause-specific mortality. In addition, a unique, amenable living environment (23–25) can positively influence happiness and related parameters, although it is connected to wealth and health.

According to Inglehart and Klingemann (26) and Ye et al. (8), the differences in wellbeing vary relatively little over time within a country or region (vertical temporality), but between countries, it can vary even by one to ten (horizontal temporality). The relative vertical stability is connected to people's adjustment if they repeatedly experience negative affect. They become less demanding (27–29).

Since the end of the last century, the countries in South-Eastern Europe (SEE) have stabilized, some in connection with their membership in the European Union (Croatia, Slovenia) and others in a protracted accession process like Bosnia-Herzegovina, Montenegro, North Macedonia, and Serbia, all with related Slavic languages and therefore cultural commonalities, and the bilingual territory of Kosovo[1] with Albanian and Serbian language. In addition, all of them except Albania belonged to the Yugoslavian state, established after World War I in 1918/19, broken apart in the civil wars of the 1990's. Except for Kosovo, all are characterized by the dominant Christian—catholic or orthodox—religion. Women have been confined to traditional roles for centuries under the long-lasting Ottoman rule[2] in these countries (30), likely to be less individualistic and more collectivistic (31) than in neighboring central and Western Europe. The recent generations of women enjoyed increasingly equal acceptance, especially during the socialist period under Tito (1892-1980), and are now requesting their place in the modernizing South Eastern societies (32). Several recent articles, theoretical approaches, and studies address determinants of subjective wellbeing of the general population or vulnerable groups in the European and SEE regions. However, women are rarely targeted as the sole population.

This study explores determinants of women's subjective wellbeing in three selected countries of South-Eastern Europe: Montenegro, North Macedonia, and Serbia. We hypothesize that several factors influence different groups of women's subjective wellbeing. Furthermore, we expect to observe differences between selected countries, highlighting horizontal temporality despite a joint historical development.

METHODS

In a cross-sectional approach, we analyze the latest MICS surveys available from the UNICEF database (33) of women 15–49 years old and implemented between 2018 and 2019 in three South-Eastern European (SEE) countries (see **Box 1**) with related Slavic languages, history, and culture, i.e., Montenegro, North Macedonia, and Serbia, which comprise 50.4% of the former Yugoslavia's population. Bosnia-Herzegovina (BiH) and Kosovo could not be integrated, as for BiH the survey data from 2020 are not yet available, and for Kosovo, the dependent variables of happiness and life satisfaction, unfortunately, have not been reported in the latest survey. Regarding the two remaining

[1] All references to Kosovo in this article should be understood to be in the context of the United Nations Security Council Resolution 1244/99 http://www.un.org/docs/scres/1999/sc99.htm.

[2] The Ottoman rule lasted from the battle of Kosovo in 1389 until the Berlin Congress in 1878.

Yugoslavian succession states, the last MICS in Croatia dates more than 20 years back. For Slovenia, a survey has never been run. Repeatedly, we draw on experience presented in our first publication about women's happiness in Montenegro (7). Therefore, we use Montenegro as a reference country where required. Furthermore, we investigate whether the variable groups related to subjective happiness, i.e., those describing grief and threats and those relating to health services during pregnancy show differences between analyzed countries.

BOX 1 | Latest MICS surveys.

Bosnia-Herzegovina	(2020?)
Croatia	1996
Kosovo	2020
Montenegro	**2018**
North Macedonia	**2019**
Serbia	**2019**
Slovenia	-.-

Participation has been determined as follows, taking the reference example of Montenegro (34): of the 6,000 households selected for the national sample, 5,416 were found occupied; 3,826 households were successfully interviewed, corresponding to a household response rate of 70.6%; and 2,928 women (age 15–49 years) were identified in the interviewed households, corresponding to 76.5%. Of these, 2,276 were successfully interviewed, yielding a response rate of 77.7%. In the case that all 5,416 households of the sample were successfully interviewed, not 2,928 but ∼4,145 women in the interviewed households could have been identified (given the same percentage of women per household i.e., 76.5%). The 2,276 interviewed women make up only 54.9% of the representative sample related to this potential sample size of 4,145 women. It remains an open question whether self-selective dynamics played a role here.

The MICS datasets[3],two-stage stratified cluster samples, for the three available South-Eastern European countries contain, for e.g., for our standard reference Montenegro, 383 variables (out of which 27 relate to organizational procedures and 4 to the dependent variables of happiness and life satisfaction). This leaves in the example of Montenegro 352 independent variables with a potential impact for the analysis, almost all categorical. The basic questionnaire can be found in the UNICEF database (33), nearly identical for all three countries (where not, this is mentioned in the tables). To reduce the number of variables and select a manageable set of potential predictors, we applied a module for "Feature selection and variable screening" (35) as a pre-processor for predictive data mining. In a second step, we checked all remaining variables whether they have a response rate >50% in the sample of Montenegro. Otherwise, we did not make further use of them. Due to its relevance, we allowed for one exception: the year of first birth (CM16BY). For relevant groups with more than six variables, we kept only three to four variables providing the best spread and showing a prevalence of positive answers of ≥1.0% in Montenegro. This approach to reducing complexity concerned the variable group "Heard of contraceptive methods" (CP0A-N) and "Current use of contraceptive methods" (CP4A-N) further down in **Table 1**. Finally, in a third step, we eliminated all variables not available in all three countries subjected to our analysis (with one exception in **Table 2** further down and one in **Table 3** regarding the descriptive presentations there). For WB15 ("Duration of living in current place"), we replaced the answer "Always/since birth" with the age of the woman.

The final list of potential determinants and their rates of missing values is shown in **Table 4**, together with the four dependent variables of happiness and life satisfaction. Furthermore, we categorized the remaining variables according to three themes: I. medical assistance; II. grief and threats; III. marriage and children. A preceding category assembles the four available discriminators A–D: age of women, education, region, and wealth. We did not use weighted averages between the three selected countries; we wanted to analyze the "real" situation independent of differing determinants.

The various MICS provide several categorical (YES/NO) indicators for health care quality. We checked the professional assistance provided to the mother during pregnancy and delivery (**Table 5** further below). As the total number of births in the last 2 years is unknown, the estimation was done based on whether women had one or more children during the previous 2 years (answer: YES/NO). However, it is unlikely that a more significant number had two or even three deliveries during this short period. For Serbia, postnatal services were unavailable, but we added the two variables, "Mother checked after delivery" and "Baby checked after delivery," available for Montenegro and North Macedonia.

Deviating from our first analysis (7), we extended the concept of defining the dependent variable here, analogous to Inglehart et al. (36), who suggest that combining the variables of happiness and life satisfaction provides a broader-based and more reliable indicator of the subjective wellbeing (SWB) levels of societies than do either of its two components (for the involved variable names in the following formula see **Tables 4** or **6** at the last group of variables). For this procedure, we use the formula proposed by them, where the dependent variable SWB = LS2 - (2.5 * LS1). The maximum value here is SWB = 10 – (2.5 * 1) = 7.5 and the minimum is SWB = 1 – (2.5 * 5) = −11.5 (the distance being 19 points), not counting missing values and zero values.

The MICS dataset is also analyzed by subnational regions, where available, to represent a potentially closer social relatedness. In addition, we use available parameters at the national level to link to each other all three social layers, i.e., the individual micro-, the regional meso-, and the national macro-level (34). At the national level, the following are available: population density, female life expectancy, gross domestic product (GDP), distribution of gender in the national workforce (job information is missing in MICS), human rights index, corruption index, trust level, human freedom index,

[3]Permission obtained from UNICEF/MICS team by mail of 24.04.2020. This is a secondary analysis of the UNICEF surveys for which the authors obtained access and approval by UNICEF as the owner of the data.

TABLE 1 | Knowledge and use of selected birth control methods.

Distribution by	Information or Practice	Montenegro		North Macedonia		Serbia	
		Spearman Rank r	*p*-value equal to	Spearman Rank r	*p*-value equal to	Spearman Rank r	*p*-value equal to
Age	**Ever heard of…**						
CP0E	Implants	−0.012	0.554	−0.070	0.000	0.010	0.553
CP0I	Diaphragm	−0.081	0.000	−0.041	0.000	−0.103	0.000
CP0M	Withdrawal	−0.161	0.000	−0.165	0.000	−0.113	0.000
Education	**Ever heard of…**						
CP0E	Implants	−0.180	0.000	−0.250	0.000	−0.118	0.000
CP0I	Diaphragm	−0.292	0.000	−0.355	0.000	−0.190	0.000
CP0M	Withdrawal	−0.154	0.000	−0.130	0.000	−0.094	0.000
	Ever used…						
CP3	Any contraceptive method	−0.112	0.000	−0.115	0.000	−0.161	0.000
Wealth	**Ever heard of…**						
CP0E	Implants	−0.168	0.000	−0.218	0.000	−0.085	0.000
CP0I	Diaphragm	−0.260	0.000	−0.321	0.000	−0.187	0.000
CP0M	Withdrawal	−0.168	0.000	−0.138	0.000	−0.074	0.000
	Ever used…						
CP3	Any contraceptive method	−0.136	0.000	−0.185	0.000	−0.175	0.000

TABLE 2 | Comparison of the end-nodes (defined women groups) of the three countries under consideration (for details, see the iC&RT figures in **Annexes I–III,** and the statistical evaluation in **Annex IV**).

Montenegro				North Macedonia				Serbia			
ID*	N	%	SWB Mean ±SD	ID*	*N*	%	SWB Mean ±SD	ID*	*N*	%	SWB Mean SD
01	2184	100	5.4 ± 2.5	01	2998	100	4.1 ± 3.3	01	3627	100	4.4 ± 2.9
43	247	11.3	6.1 ± 1.8	69	838	28.0	5.0 ± 2.6	29	1073	29.6	5.1 ± 2.4
42	614	28.1	5.6 ± 2.2	79	151	5.0	4.6 ± 2.7	26	154	4.3	4.6 ± 2.5
34	588	26.9	5.6 ± 2.2	66	327	10.9	4.3 ± 3.5	28	987	27.2	4.5 ± 2.6
28	202	9.2	5.1 ± 2.8	68	997	33.3	4.3 ± 2.7	39	620	17.1	4.4 ± 2.9
35	244	11.2	5.0 ± 2.3	78	342	11.4	3.1 ± 3.4	41	195	5.4	4.1 ± 2.8
31	103	4.7	4.6 ± 2.8	67	138	4.6	2.3 ± 4.5	27	180	5.0	3.4 ± 3.4
29	186	8.5	3.8 ± 3.5	64	90	3.0	2.0 ± 4.7	40	418	11.5	2.9 ± 3.7

Identification number of node respectively the identified subpopulation of women, see **Annexes I–III.*

charity index, and human development index (see **Table 7** further below).

In a first step, we performed a stepwise regression to determine the relationship between the remaining variables A-D and the SWB, despite the large scattering of the measured data. However, the coefficient of determination (adjusted R^2) is low, i.e., 4.4% in the Montenegrin model, 5.97% in the Serbian model, and 9.9% in the North Macedonian model. At the same time, the *p*-values are highly significant. Concerning the question of which R-value is appropriate and sufficient, the general view in the literature is that values above 70% are desirable (35). Some authors point out that in cases where it is about the correlation of variables and not about predictions, the *p*-value may be more critical than the R^2-value (36, 48). Even high-variability data can have a significant trend (48, 49). Nevertheless, we preferred to treat these results cautiously and performed further analyses using the data mining technique (50–52), more precisely, an interactive Classification and Regression Tree (iC&RT) (35). Unlike our first categorical C&RT analysis (7), we applied a C&RT regression here. This allowed us to present mean values for SWB and associated variances at all positions of the iC&RT trees.

a) The Interactive Trees module (iC&RT) allows the use of both categorical and interval scaled variables, is optimized for

TABLE 3 | Detailed description of the terminal iC&RT nodes (defined women groups) of subjective wellbeing of Montenegrin women.

ID*	*N* = 2184	%	SWB Mean/SD	A Years mean age of women	B Education (%) Higher Secondary Primary or less	C1 Years living in the same place	D Level of wealth (%) L1(richest)-L5
43	247	11.3	6.1 ± 1.8	36.9	S (51.4)/H (46.6)	36.7	L1 (48.2) L4 (51.8)
42	614	28.1	5.6 ± 2.2	30.7	S (49.8)/H (47.4)	13.5	L1 (44.3) L4 (55.7)
34	588	26.9	5.6 ± 2.2	27.0	S (55.4)/H (36.7)	19.2	L2 (47.8) L3 (52.2)
28	202	9.2	5.1 ± 2.8	22.6	S (58.9)/P (28.7)	15.2	L5 (100.0)
35	244	11.2	5.0 ± 2.3	42.0	S (65.6)/P (18.9) H (15.6)	25.5	L2 (51.2) L3 (48.8)
31	103	4.7	4.6 ± 2.8	47.5	S (62.1)/H (21.4) P (16.5)	47.5	L1 (28.2) L2 (28.2) L3 (31.0) L4 (13.6)
29	186	8.5	3.8 ± 3.5	40.0	P (50.5)/S (44.1) H (5.4)	24.5	L5 (100.0)

** Identification number of node respectively the identified subpopulation, see **Annexes I-III**.*

vast data sets, and is also more flexible in handling missing data[4]. The program runs predictors, one at a time, to determine the best (next) split of the starting population and the subsequent subgroups at lower levels. For example, in the General CHAID (GCHAID) module, observations with missing data for any categorical predictor are eliminated from the analysis, and variables with insufficient/lesser variance in comparison (53).

b) iC&RT allows "what-if" analyses by interactively deleting individual branches, growing other components, and observing different result statistics for the various trees (tree models).

c) One can automatically grow some tree parts, but manually specify splits for other branches or nodes to find and specify alternative predictors and partitions.

d) One can define specific splits to build economical and straightforward solutions that can easily be communicated and implemented.

e) Reloading, the tree will be restored to the same state as it was saved (54).

The advantage of high flexibility, on the other hand, requires answering the question of how to find the "right size" of a tree. A too high or low complexity can dilute the model's statement. A very complex tree provides many insights that might be overlooked in a more straightforward tree. It risks creating nodes filled with minimal numbers. So, it is up to the analyst to select meaningful trees. In this way, it compromises simplicity, accuracy, and meaningfulness. Therefore, we controlled for both aspects with cross-validation in the iC&RT model and verified this model with a cross-check of an iC&RT analysis. In the latter, the adequacy of the model solution was checked according to the one standard error rule (54–56). Both approaches provide compatible results.

RESULTS

After the selection process, described in the Methods section, to identify potential determinants of the dependent variables, Happiness and Life Satisfaction, the variables listed in **Table 6** remained for the resulting analyses, with 29 potential determinants and four dependent variables together with two integrated indices. We added selected descriptive variables in **Tables 1**, **5** below for a complete picture (maternal care and birth control).

Table 5 shows almost complete prenatal care coverage and delivery by a physician. In contrast, postnatal care of mother and child in the two available countries, Montenegro and North Macedonia, lacks appropriate coverage. A nurse or a midwife generally assists the physician in all functions with one exception: in North Macedonia, the nurse checks the baby after delivery independently in 49.0%. The data also illustrate women's subjective wellbeing through maternal care and birth control.

Furthermore, we analyzed in **Table 1** knowledge ("ever heard of…") and the use of birth control methods selected in **Table 6**. Contrary to the wealth index, age and education significantly impact knowledge and use of birth control methods except implants (did you ever hear of implants?) in Montenegro and Serbia, see **Table 1**.

We did not further explore section II in **Table 6** on grief and threats. The low level of positive answers did not allow for more advanced analyses.

As described earlier, we identified four discriminators of subjective wellbeing (SWB): age of women (WB); education (welevel); wealth index quintile (WB5); region (HH); and duration of living in the current place (WB1new[5]). The spectrum

[4]*Note: The iC&RT methodology uses the term "Node" to describe resulting subpopulations.*

[5]The answer "Always/since birth" has been replaced by the age of the women, resulting in 20 missing values.

TABLE 4 | Selection of variables with missing values.

Sections	Line number of related areas	Selection of variables/line numbers based on missing values <50% of the Montenegrin sample (*N* = 2928)	Variable Acronym	Montenegro Missing values* *N* = 2928	North Macedonia Missing values*: *N* = 3169	Serbia Missing values*: *N* = 4219
Discriminating variables A-D						
A. Age	30	30-Age of women	WB4	22.3	6.5	11.4
B. Education	31, 32, 33–41, 361	361-Education	welevel	22.3	6.5	11.4
C. Region	42–44, 46–51, 369	42-Duration living in the current place (364) 369-Region	WB15 HH7	22.3 0.0	6.5 0.0	11.4 0.9
D. Wealth	372–380	373-Wealth Index Quintile	Windex 5	22.3	6.5	11.4
Selected themes I-III						
I. Medical assistance	87–174, 276–283,	88-Prenatal care provider: Doctor 89- Prenatal care provider: nurse/midwife**	MN3A MN3B	0.0 0.0	0.0 0.0	0.0 0.0
	306–320	101-Assistance at delivery: Doctor 102-Assistance at delivery: nurse/midwife**	MN19A MN19B	0.0 0.0	0.0 0.0	0.0 0.0
II. Grief & threats	52–54, 232–267	52-Ever had a child who later died (357) 232-236 Beating by husband 261-266 Felt discriminated	CM8 DV1A-E VT22A-F	22.3 22.3 22.3	6.5 6.5 6.5	11.4 11.4 11.4
III. Marriage & children	45, 46, 55–86, 175–231, 268–275, 284–305, 353, 355	46-Any sons or daughters living with you 58-Year of last birth*** 60-Year of first birth*** 62-Life births in last two years 175–187 Heard of contraceptive methods 191-Ever used method to avoid pregnancy 192-204 Current contraceptive methods 229-Availability of private place for washing during last menstrual period	CM2 CM15Y CM16BY CM17 CP0A-N CP3 CP4A-N UN17	45.3 42.3 54.0 45.3 22.3 34.4 22.3 26.3	30.0 1.2 0.5 30.0 6.5 54.0 0.0 0.0	11.4 34.8 34.8 34.8 11.4 58.3 0.0 0.0
		268-Currently married or living with a man 353-Age at first marriage/union of a woman	MA1 WAGEM	22.3 22.3	6.5 25.8	11.4 30.7
		355-Children ever born	CEB	42.7	6.5	11.4
Dependent variables	345	Estimation of overall happiness	LS1	22.3	6.5	11.4
	346	Satisfaction with ladder step	LS2	22.3	6.5	11.4
	347	Life satisfaction in comparison with last year	LS3	22.3	6.5	11.4
	348	Life satisfaction expectation 1 year from now	LS4	22.3	6.5	11.4

Variables are excluded if <50% of the total sample size of N=2928 in the reference Montenegro are available.

**% of sample size N.*

***Assisting the physician or alone.*

****Alternative variable names: BH4_FIRST and BH4_LAST for North Macedonia and CM15AY for Serbia.*

of SWB ranges from−11.5 to +7.5, i.e., 19 units equal to 100%. Based on the iC&RT analysis, the nodes describe a defined population i.e., a group of similar women.

The results of the iC&RT analyses in **Table 2** and the corresponding figures in **Annexes I–IV** demonstrate the distribution of subjective wellbeing (SWB) according to the four discriminators**,** subjecting the female population of the three chosen countries, based on the respective MICS survey data.

The SWB levels at the starting nodes in **Table 2** differ only to a small extent (Cohen's D is between 0.07 and 0.43), nevertheless significant at $p < 0.05\%$. Montenegro is ranked first with 88.9% of the maximum (full range from −11.5 to +7.5 = 19 points equalling 100%), followed by Serbia with 83.7%, and North Macedonia with 82.1%. Accordingly, the end-nodes indicate a relatively narrow spectrum of SWB in the three populations between the highest and lowest group in each: between 80.5 and 92.6% for Montenegro, 64.2 and 86.8% for North Macedonia,

TABLE 5 | Professional assistance during pregnancy.

	Variable name	Montenegro	North Macedonia	Serbia
Variable abbreviation	**Total number of at least one live birth in the last 2 years (CM17)**	432 (100%)	574 (100%)	660 (100%)
MN3A&B	**Prenatal care provider:**			
	doctor	426 (98.6)	563 (98.1)	655 (99.2)
	nurse/midwife (alone)	1 (0.2)	2 (0.3)	2 (0.3)
MN19A&B	**Assistance at delivery:**			
	doctor	405 (93.7)	555 (96.7)	619 (93.8)
	nurse /midwife (alone)	26 (6.0)	19 (3.3)	40 (6.1)
PN14A&B	**Baby checked after delivery:**			
	doctor	295 (68.3)	258 (44.9)	n.a.
	nurse/midwife (alone)	21 (4.9)	281 (49.0)	
PN23A&B	**Mother checked after delivery:**			
	doctor	177 (41.0)	284 (49.5)	n.a.
	nurse/midwife (alone)	4 (0.9)	35 (6.1)	

and 75.8 and 87.4% for Serbia. The spread between the least and the most wellbeing women group (comparing end-nodes) is the narrowest in Serbia (11.6%), the second in Montenegro (12.1%), and the highest in Macedonia (22.6%).

In **Table 3**, we add for Montenegro, considered the reference country (7), a detailed description of the iC&RT end nodes (finally determined population groups). The first three nodes (34, 53, 54) with the highest SWB means (between 5.6 and 6.1 of a maximum of 7.5) are characterized by a secondary or higher level of education, women of younger age (between 27 and 37 years), and, for node 43, living for several decades at the same place. As can be expected, they belong to the wealthiest population layers, L1 or L2. Still, there is also a group (between 52 and 56% in these three groups) that, despite secondary or higher education, belongs to the lower wealth levels (L3 or L4). The SWB level of these first three nodes, comprising two-thirds of the female population (66.3%), ranges between 5.6 and 6.1, corresponding to the 90th decile of the possible SWB spectrum.

The remaining four nodes (28, 29, 31, 35) are characterized by smaller shares of highly educated women, but still a majority of women with secondary education except for the lowest group (node 29) with 50.5% of primary education only. This population comprises a majority of women in the higher age group (age 40–47.5) except for the 202 (5.1%) in node 28 with an average age of 22.6, obviously at the beginning of their professional career. Only 28.7% in this group and 100% of the women in node 29 belong to the lowest wealth level comprising 8.5% of the Montenegrin female population. This last group still reveals an average SWB level of 3.8, just in the 80th decile (80.5%).

North Macedonia ($N = 2998$) ranks in the top group at a node mean of 5.0 or 86.6% of the maximum SWB, comprising 28.0% of the female population 15–49 years old. The upper four nodes in **Annex I** represent 77.2% of the female population at SWBs between 4.3 and 5.0. The main splitting variables are the wealth index, age, and the Macedonian regions.

Serbia shows a somewhat higher top-level SWB of 5.1 or 87.4% for a group of $N = 1{,}073$ or 29.6% of the total ($N = 3{,}627$). Like in Montenegro and North Macedonia, wealth and age are the most critical splitting variables. However, the regions are highly relevant for Serbia, determining the end-nodes for 73.7% of the population.

Three-quarters of the difference in subjective wellbeing between the top 10 and bottom 10 countries and regions, according to the World Happiness Report of 2016 (57), can be explained by the following: (1) social support so that you have friends and family to count on, (2) freedom to choose what you do in life, (3) generosity and how much people donate to charity, 4) absence of corruption in business and government, (5) gross domestic product, and (6) healthy life expectancy.

At the national level, the most available relevant information for all seven Yugoslavian successor states is listed in **Table 7**. The indices selected suggest a superior position for Montenegro, except for the human rights index (Serbia ranked surprisingly 0.25 values higher in 2019) and the economic freedom index (North Macedonia ranked 0.40 higher). Sachs (57) summarizes the different views under six terms: mindfulness, consumerism, economic freedom, dignity of work, good governance, and social trust, modified further by Helliwell et al. (41) based on the results of Gallup surveys, including up to 157 countries (58, 59).

DISCUSSION

Modern strategies for health system development try to empower women and promote gender equality in governance and management at the macro (society and policy), meso (communities and institutions), and micro (social interaction in departments) levels. The WHO approach to gender mainstreaming (60) refers to projects and institutions striving to build capacities in developing gender equality, promoting sex-disaggregated data and gender analysis, and establishing accountability. Since women account on average for 70% of the workforce for health (61), gaps in health workers will decrease only by addressing the gender dynamics of the workforce. In its 5-year strategy (2019-2023), WHO (62) is committed to empowering countries for gender equity and a human rights approach in the day-to-day activities of the health sector.

TABLE 6 | Women's descriptive characteristics and subjective wellbeing (SWB).

Sections	Line numbers and variable names (abbreviated)	Acronyms	MN	NM	SRB
	Total sample, incl. missing values		2928	3391	4378
Standard discriminators	**National values are given as valid % or as specified**				
A. Age of women	30-Age of women (average)	WB4	32.6	32.5	33.5
B. Education	361-Education: The highest level of the school attended (percent higher than secondary level)	welevel	32.6	33.8	41.1
C. Region	42-Living in current place since birth (percent) 369-Region (percent in the central region)	WB15 HH7	46.8 35.8	51.7 19.7	53.7 24.3
D. Wealth	373-Wealth Index Quintile (percent of quintiles 4 & 5)	Windex5	40.9	31.8	41.5
Themes I – III					
I. Medical assistance (All variables as a percentage)	88-Prenatal care provider: doctor 89- Prenatal care provider: nurse/midwife* 101-Assistance at delivery: doctor 102-Assistance at delivery: nurse/midwife*	MN3A MN3B MN19A MN19B	98.6 11.3 93.7 89.6	98.1 5.4 96.7 92.7	99.2 19.1 93.8 92.3
II. Grief & threats (All variables as a percentage)	52-Ever had a child who later died (357) 232-If she goes out without telling her husband, wife-beating justified	CM8 DV1A	1.7 2.2	2.6 4.4	1.0 0.5
	233-If she neglects the children: wife-beating justified 234-If she argues with her husband: wife-beating justified 261-In the past 12 months, felt discriminated against ethnic or immigration origin	DV1B DV1C VT22A	4.3 1.6 1.4	9.4 4.6 3.5	1.4 0.7 1.5
	262-In the past 12 months, felt Discriminated against gender	VT22B	1.2	4.2	3.1
	263-In the past 12 months, felt discriminated against for religion or belief	VT22E	1.2	1.6	0.7
III. Marriage & children	46-Any sons or daughters living with you (percent) 58-Year of last birth (years ago, median) 60-Year of first birth (years ago, median) 62-Life deliveries in the previous 2 years (percent) Knowledge of birth-control methods as a percentage:	CM2 CM15(A)Y** CM16BY** CM17	98,1 4 12 26.9	98.2 6 11 24.2	97.5 4 9 24.0
	179-Heard of: implants 183-Heard of: diaphragm 186-Heard of: withdrawal 191-Ever used a method to avoid pregnancy 194-Current method: IUD 198-Current method: male condom	CP0E CP0I CP0M CP3 CP4C CP4G	28.6 53.4 83.6 12.0 2.0 3.8	39.4 51.8 93.2 23.6 1.0 10.1	46.9 79.9 97.9 37.0 1.4 14.4
	202-Current method: periodic abstinence/rhythm method	CP4L	1.0	1.6	8.3
	203-Current method: withdrawal 229-Availability of private place for washing during last menstruation (percent)	CP4M UN17 MA1	4.6 97.5 69.2	37.5 98.0 75.9	28.5 98.8 71.4
	268-Currently married or living with a man (percent) 353-Age at first marriage/union of women (median) 355-Children ever born (median)	WAGEM CEB	23 2	22 2	23 2
SWB and composite components	345-Estimation of overall happiness (1st of 5 levels = best), levels 1 and 2: very and somewhat happy (percent)	LS1	73.9	85.2	79.8
	346-Satisfaction with life according to ladder step (10^{th} of 10 levels = best), levels 7–10 (percent)	LS2	68.4	70.8	73.2
	347-Life satisfaction in comparison with last year (level 1 best of 3 levels, percent)	LS3	35.6	44.4	40.0
	348-Life satisfaction expectation 1 year from now (level 1 best of 3 levels, percent)	LS4	55.6	75.1	68.6
	Subjective Wellbeing: SWB = LS2 - (2.5 * LS1); range: −11.5–7.5 = best (mean); *N* = 2,204 (missing 24.7%)	SWB	5.35	4.05	4.39

**Assisting the physician or alone.*

***Alternative variable names: BH4_FIRST and BH4_LAST for North Macedonia and CM15AY for Serbia.*

*Reference is the total samples of N = 2.928 resp. 3169 resp. 4219 minus missing values (see **Table 1**).*

The variable groups CP0, CP3, and CP4 are represented here only by selecting a small number of typical items (8 out of 27).

MN, Montenegro; NM, North Macedonia; SRB, Serbia.

TABLE 7 | National parameters of potential relevance, available for the six successor states of the former Yugoslavia compared to Austria.

Country	Reference	Austria	Bosnia-Herzegovina	Croatia	Montenegro	North Macedonia	Serbia	Slovenia
1) Population density/skm 2018	(37)	107	65	72	46	83	80	103
2) General and Female life expectancy, 2018 (years)	(38)	82.0 84.2	77.3 79.8	78.6 81.6	76.9 79.3	76.7 78.8	75.9 78.4	81.6 84.5
3) GDP 2019 (PPP$)	(39)	58.641	14.895	28.829	19.931	16.609	18.840	39.038
4) Share of women and men (%) employed in the labour force, 2019	(40)	55.9 67.1	32.8 51.1	45.2 57.6	49.9 62.2	44.9 66.1	47.1 62.7	53.2 63.0
5) Human Rights Index (1–10 best), 2019	(41, 42)	8.90	5.47	7.69	6.18	5.91	6.43	8.83
6) Corruption Index:	(43)							
Ranking, 2020 (1 = best)		15	111	63	67	111	94	35
Score, 2020 (100 = best)		76	35	47	45	35	38	60
7) Trust Levels, 2008-2010 (100 = best)	(44)	36	27	20	25	19	12	24
8) Human Freedom:	(45)							
Ranking, 2019 (1 = best)		13/162	57/159	38/159	51/159	60/159	55/159	35/159
Index (1–10 best):								
Economic freedom		7.71	6.61	7.36	6.77	7.17	6.75	7.33
Personal freedom		9.25	7.93	8.47	8.11	7.25	7.85	8.77
9) Charity, Ranking 2019 (1 = best)	(46)	15	90	132	116	130	129	47
10) Human Development Index, 2018 (0–1 best)	(47)	0.922	0.769	0.851	0.816	0.759	0.799	0.917

A recent review (63) pointed out that female health workers who deliver most of the care in all settings face barriers at work not faced by their male colleagues. This situation undermines their wellbeing and livelihood and constrains progress on gender equality. It negatively impacts health systems and the delivery of quality health services.

The three countries in this analysis represent about one-half of the former Yugoslavian population and still did not yet access the European Union. They have three more qualities in common: a former socialist constitution, the orthodox religion, and the long-lasting Ottoman rule. In addition, they rank relatively high, between the 42nd and 75th, positions in the World Happiness Index [(64), table 2.1], with an increasing tendency over the last years for all of them. We focus on young and middle-aged women under the original assumption that the cited history culturally determines them. However, we found the women in these three countries predominantly happy, measured by the more stable index of subjective wellbeing (SWB), which integrates overall happiness with life satisfaction**.** In addition, the women's outlook for the next year is very positive, increasing by 20% for Montenegro, 31% for North Macedonia, and 29% for Serbia.

Montenegro takes the top position underlined in our comparative analysis by comparing national indices. An explanation of Montenegro's unique position concerning its women is possibly a higher GDP, a higher share of the female workforce, a lower corruption index and score ranking, a better charity ranking, a better human development index, and accordingly, a higher life expectancy for both genders. The only exception is the human rights index of Montenegro, with a value of 6.18 in 2020 (in 2015: 6.92), whereas Serbia in 2020 takes the top position with 6.43 out of 10 points. In an earlier detailed analysis focused exclusively on Montenegro (7), we found for the two upper categories, very happy and happy (out of 5), a similar percentage of 96.7. However, to close up to Austria (first column in **Table 7**), a non-Yugoslavian country historically most related, will still need more years.

The generally high level of SWB and related parameters may also result from the high level of medical care expressed by the dominating physician's role referring to the example of medical care during pregnancy: health and happiness are mutually related (31, 65, 66).

The level of wealth is the most critical splitting variable in Montenegro, defining groups of similar SWB. In contrast, the regions play a dominant role in the two larger territories of North Macedonia and especially Serbia, in addition to age. However, human development models suggest that the emphasis shifts from the pursuit of happiness through economic means toward a broader perception by maximizing free choice in all realms of life, an option to increase perceived SWB (67, 68). The belief that one has free will and control over one's life is closely linked with happiness (69), and this link seems universal. Simovic (70) argues that Montenegro's extraordinary situation is due to the basic principles enshrined in the Montenegrin constitution, which are developed by a series of laws governing the exercise of the right to work, right to education, family relations, health, and social care.

To speed up interventions for gender equality, in 2017, WHO established the Gender Equity Hub (GEH), co-chaired by

WHO and Women in Global Health under the umbrella of the Global Health Workforce Network. The GEH brings together key stakeholders to strengthen gender-transformative policy guidance and the implementation capacity for overcoming gender biases and inequalities in the health workforce, supporting the implementation of the Global Strategy on Human Resources for Health: Workforce 2030 (63). Gender analysis, empowerment, and mainstreaming became significant cross-cutting issues in developing capacity for health system management. There is much evidence confirming that the lack of gender parity in higher-level decision-making positions and leadership in the health workforce can influence the efficiency and quality of health services. In contrast, discrimination in health service settings can compromise Universal Health Coverage (64).

Our analysis has some limitations admittedly due to the quality of the sampling scheme and the considerable percentage of missing data. In the methods section, we pointed to the weaknesses of the sampling procedure as the potential sample size for women, e.g., for Montenegro aged 15–49, $N = 3{,}826$, leaving us with a participation rate of 54.9%. Furthermore, the low rates of positive answers in section II of **Table 6** related to grief and threats did not allow more detailed analysis. The high rates of missing responses in section III of **Table 6** on "Marriage & children" may have invalidated some of our results. Unfortunately, two indicators of high relevance in our context are missing in the MICS database: information on occupation/employment and social support. For these deficits, we chose a stable data mining approach.

CONCLUSIONS

The three selected South-Eastern European countries of the former Yugoslavia (Montenegro, North Macedonia, and Serbia) present high levels of subjective wellbeing and a narrow range between the lowest and highest female population groups. Women in Montenegro take a top position regarding their subjective wellbeing.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https:/mics.unicef.org/surveys.

AUTHOR CONTRIBUTIONS

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

ACKNOWLEDGMENTS

We thank Prof. Genc Burazeri, Maastricht University, The Netherlands, for his detailed advice on the analyses in this study.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.873845/full#supplementary-material

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