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Experts’ opinions on aging and public health

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Experts' opinions on aging and public health

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Editorial: Experts' opinions on aging and public health

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Editorial on the Research Topic
Experts' opinions on aging and public health

Consistent with the United Nations Decade of Healthy Aging (1), the Specialty Chief Editors of the Aging and Public Health section of Frontiers in Public Health issued a Research Topic to solicit Expert Opinions on Aging and Public Health. The overall goal was to highlight recent advances in conceptualization, measurement, and intervention strategies to further understanding about the needs of a rapidly aging world and promote healthy aging in diverse settings. This Research Topic addresses the most salient factors that act as facilitators or barriers to healthy aging including: (1) lifestyle and behavior; (2) interventions for healthy aging; (3) technology and innovations; (4) built and social environments; and (5) workforce development for public health and aging. Additionally, it recognizes the importance of precision health, health equity, and implementation science. In total, the Research Topic contains nine expert opinions from *international leaders* whose seminal research and thinking have shaped the way we conceptualize aging in the field of public health.

This Research Topic reflects and reinforces major themes in aging and public health research and practice, such as the importance of interdisciplinary team science research and participatory research approaches (2). As part of a new Australian government research program designed to identify better solutions to major healthcare threats, Thomas et al. conceptualize a transformative model for chronic disease prevention and management that integrates precision medicine, behavior change programs, and digital health solutions. The INTEGRATE model addresses both physical and mental health across the life course. Building on this integration theme, Dubé et al. use social isolation and the aging brain test case to recognize that aging is more than decrements and tout the power of positive attributes (e.g., multi-level resilience). They coined the term "precision convergence" to bridge biology and neuroscience mechanisms with social systems that impact real-world behavior. This integrative approach supports the centrality of health equity as a major goal of aging and public health research and practice. Summarizing lessons learned from a virtually-hosted Health Equity Innovation Summit in personalized medicine, Ory et al. emphasize that new paradigms are needed to ensure the inclusion of underrepresented populations, and especially older adults. Underscoring the importance of community collaborations to achieve equitable access to state-of-the-art treatments, they conclude that for maximal population health, personalized medicine must be re-envisioned to consider the full continuum of care and care partners.

Technology has become ever-abundant in the 21st century and is often viewed as a solution for limited human resources (3). Yet, understanding the true value of technology requires a social technology approach. Kleinman et al. known for their understanding of the intersection of health and culture, posit several social technology tenets for assisting older adults, their families, and communities. These include fostering multidisciplinary collaboration, attending to ethical and humanistic standards, engaging with social service providers, promoting social justice; enhancing social integration through age-friendly and intergenerational programs; and employing best practices. Although technology-based care options for older adults are expanding widely, harmful stereotypes about their technology-related abilities, preferences, and fears may hinder access and engagement in research studies. Clair et al. provide several examples of their community-centered approaches where researchers can learn from their participants and reduce "researcher bias" by employing person-centered research strategies.

Evidence suggests the environment substantially influences lifestyle behaviors and associated health outcomes for older adults (4). Reflecting on the World Health Organization (WHO) International Active Aging Framework (5), Portegijs et al. explicate the advantages of activity-friendly environments for healthy aging, especially when viewing complex dynamic interactions underlying different physical, social, and technological environments. Their commentary amplifies research from a prior Frontiers in Public Health Research Topic on Healthy Aging and the Community Environment (6). Additionally, social environments have received increased attention with the awareness that social isolation and loneliness are major health risk factors akin to previously documented lifestyle behaviors like smoking (7, 8). Smith et al. offer nine actionable societal- and community-level solutions to help communities collaboratively combat social disconnectedness and its deleterious health outcomes. These recommendations reflect a consensus of several national and international working groups to better conceptualize and measure social connectedness.[1]

The Research Topic concludes with two cross-cutting implementation issues. The first is an appreciation of the global health professional shortage, especially for geriatric care, which negatively impacts the quality-of-care older adults receive (9). This is a long-standing problem that is exacerbating with population aging and fallout from the COVID-19 pandemic. In this context, Evashwick muses about strategies for reducing shortages in geriatric care through accrediting entities' greater recognition of, and requirement for, geriatric competencies in all fields and across all levels of training.

The second cross-cutting issue reinforces the importance of dissemination and implementation science (DIS) for understanding the public health impact of programs, policies and practices (10). Estabrooks and Glasgow, founding members of the National Consortium on RE-AIM Planning and Evaluation Framework (www.re-aim-org), reflect on processes involved in developing a DIS research agenda for aging and public health. Drawing on their experiences with the RE-AIM and PRISM frameworks, they stress the importance of recognizing contextual factors and addressing health inequities. This concluding article underscores the evolution of various DIS frameworks and poses key questions about the "what, when, how, and why" of DIS research that will help accelerate the translation of evidence-based interventions for an aging world.

In summary, contributing experts from Australia, North America, Asia, and Europe provide thought-provoking commentary in this Research Topic on major concepts, methods, and interventions to advance research and practice on aging and public health.

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Transforming global approaches to chronic disease prevention and management across the lifespan: integrating genomics, behavior change, and digital health solutions

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Chronic illnesses are a major threat to global population health through the lifespan into older age. Despite world-wide public health goals, there has been a steady increase in chronic and non-communicable diseases (e.g., cancer, cardiovascular and metabolic disorders) and strong growth in mental health disorders. In 2010, 67% of deaths worldwide were due to chronic diseases and this increased to 74% in 2019, with accelerated growth in the COVID-19 era and its aftermath. Aging and wellbeing across the lifespan are positively impacted by the presence of effective prevention and management of chronic illness that can enhance population health. This paper provides a short overview of the journey to this current situation followed by discussion of how we may better address what the World Health Organization has termed the "tsunami of chronic diseases." In this paper we advocate for the development, validation, and subsequent deployment of integrated: 1. Polygenic and multifactorial risk prediction tools to screen for those at future risk of chronic disease and those with undiagnosed chronic disease. 2. Advanced preventive, behavior change and chronic disease management to maximize population health and wellbeing. 3. Digital health systems to support greater efficiencies in population-scale health prevention and intervention programs. It is argued that each of these actions individually has an emerging evidence base. However, there has been limited research to date concerning the combined population-level health effects of their integration. We outline the conceptual framework within which we are planning and currently conducting studies to investigate the effects of their integration.

KEYWORDS

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Introduction

The world is slowly emerging from one of its most challenging periods in modern human history with the COVID-19 pandemic and its aftermath. Before the COVID pandemic the focus was on Chronic/Non-Communicable Diseases (NCDs). The WHO President (1) then warned about the growth in chronic disease burden. The significance of NCDs was recognized in the United Nations 2030 Agenda for Sustainable Development, which set targets to, *"reduce by one third premature mortality from noncommunicable diseases through prevention and treatment, and promote mental health and well-being"* (2). Unfortunately, it is now clear that COVID-19 has contributed to major upticks in underlying and consequential chronic illnesses and diseases from an already high base (3). We now seem to be in an even worse position than before. We have a syndemic driven by the existing chronic disease pandemic overlaid by the newer COVID-19 pandemic (4). A key challenge in the syndemic is to provide adequately resourced and well-trained public and clinical health workforces (5–7).

The burden of chronic diseases and illness in the human population

The burden of chronic illness globally has increased over time, accounting for the major part of global disease burden (8, 9). The epidemiology of chronic disease burden varies from country to country but most countries whether developed or developing have high chronic disease burden. The Lancet global burden studies chronicle the burden of 369 diseases and injuries in 204 countries and territories. They show that chronic conditions caused 74% of all deaths worldwide in 2019, rising from 67% of deaths in 2010. The mortality data reflect high prevalence's of chronic conditions across populations. For example, in Australia, the Australian Institute of Health and Welfare (10), has noted 47% of Australians have at least one chronic disease with 20% having 2 or more. 51% of hospitalizations involve chronic disease, 90% of deaths and disease burden is borne disproportionately by adults of lower SES and those living in remote areas. These results are consistent with those globally and in many countries. The USA NIH (11) has noted "*currently, some 50% of the US population has a chronic disease, creating an epidemic, and 86% of healthcare costs are attributable to chronic disease.*" In the United Kingdom a similar epidemiological pattern is evident with close links between traditional physical chronic diseases and associated mental health disorders (12). These studies show increased prevalence across the lifespan threatening healthy aging.

The contribution of mental health disorders, including addictions, to population disease burden

Mental health disorders including addictions are now an increasing challenge facing humanity (13, 14) with 20 percent of global disease burden. One might be forgiven for labeling recent decades as the "Age of Addiction" (15) with the addiction "traditionals" of alcohol, cannabis, and other substances and new synthesized agents overlaid by newly recognized behavioral addictions (16) (see the WHO ICD (17) and AMA DSM) (18). Of the behavioral addictions, the first was Gambling Disorder (GD) – which continues to be neglected in terms of research and development of new interventions. GD is linked to high levels of mental and physical health comorbidities, health economic costs, homelessness, and suicidality (19, 20). In addition to addictions, there is strong growth in the population prevalence's of mood disorders and anxiety (21). Interpreting the true growth in mental health disorders has some nuances. Recognition of the importance of mental health disorders (12, 22) has also led to increased prominence in national health surveys and public health epidemiological studies. These changes in population health study content make it difficult to assess the true extent of the underlying growth in the population prevalence of such disorders. Another problem is that the most pressing mental health conditions are seldom appropriately measured in public health epidemiological studies – especially GD. These issues are examples of "what gets measured gets managed" and contrariwise. There are many instances where inclusion of measures has improved health services and policy making (23). For example, mental health measures are now an increasingly prominent component of clinical datasets and such conditions are receiving greater clinical effort and funding. The same is true for chronic diseases in general which are now centrally located in health policy and service design in many countries.

The evidence base provided by disease burden and epidemiological studies strongly reinforces the WHO's alarm. What therefore is to be done? How can the global chronic diseases/long-term conditions pandemic be better addressed? Below we recommend an integrated population-level approach involving (1) large-scale measurement of polygenic and multifactorial risk factors in order to develop and rigorously validate clinically useful prediction tools and algorithms; (2) early and sustained, effective management of chronic diseases using advanced behavior change interventions and (3) digital health approaches to improve the efficiency and reach of interventions and health services at a wider population level.

Development, validation, and deployment of risk prediction tools using polygenic and multifactorial risk data

Early identification of people at risk of chronic illness and early intervention are key to reducing population chronic disease burden. Unfortunately, this obvious game changer is infrequently implemented in many public health regimens. We now have much better technology available to develop and validate evidence-based risk prediction tools and algorithms, and to demonstrate their value by leveraging digital tools that can be embedded within at-scale screening and treatment programs. We already have the technology to develop and validate useful risk prediction tools and algorithms but we contend that we are not yet systematically conducting such research and implementing resulting tools at the required pace in large-scale studies as outlined in the recent International Common Disease Alliance Polygenic Risk Score Task Force report (24). The first contact with many people with chronic disease risk is after they have already developed it (25, 26). For mental health disorders, delays in presentation and intervention can be particularly long, adding to the burden of disease. Obsessive-compulsive disorder (OCD) is one of the top ten leading causes of disability in the developed world and has a typical duration of untreated illness of 10 years (27). While less well studied, a similar duration of untreated illness has been reported for gambling disorder – around 9 years in affected individuals presenting for treatment (28).

Polygenic and multifactorial risk prediction can play a major role in delivering early warning of impending chronic diseases (29) including traditional chronic diseases such as cardiovascular disorders (30), metabolic disorders (31), and cancers (32). While more research is certainly needed, initial data suggest some promise for mental health disorders (33) including gambling disorder and newer concepts such as gaming disorder (34, 35). Wider implementation of such strategies has the potential to drive down the costs of what are now mature and proven technologies, but already they are affordable. The costs associated with inaction with chronic diseases are substantial (36). The potential cost reductions in health care costs and the net benefits of prevention, early detection and intervention are well established in principle. It is our view that humanity cannot afford to further delay polygenic and multifactorial risk prediction, early diagnosis and intervention.

Beyond the need for data collection and linked rigorous validation, to evaluate the potential value of incorporating polygenic and multifactorial risk prediction into routine practice, the global public health and health care workforces need to be trained to use these tools, to effectively communicate the meaning of risk and risk management to the community. Such training is relatively common for some conditions but neglected in other conditions. In the United Kingdom, there has been recent work to promote the wider use of genomics in General Practice (37, 38).

The prevention and management of chronic diseases

Lifestyle risk factors make a major contribution to the chronic disease burden over the life course. Many of the same risk factors contribute to multiple chronic diseases. Given the high contribution of these behavioral risk factors to multiple chronic diseases, and, that these diseases comprise such a high proportion of total disease burden, it is obvious that public health and clinical workforces need strong chronic disease program prevention skills. Inclusion of such matters in the medical and clinical health curriculums is an essential and welcome innovation to contemporary chronic disease management (39–41).

It is important to understand that treatment for the various chronic diseases must follow recognized evidence based clinical and population health prevention guidelines. Study of these guidelines show that there is a high degree of commonality in the risk factors that contribute to chronic diseases. Advanced behavior changes skills facilitate more effective prevention and management of chronic disease.

Some of this work on expanding training across health systems has been conducted by members of the authorship team. The training has been directed at public health practitioners and clinical workers in public health programs. The Happy Life Club originated in Australia and was then translated to China in various major cities and provinces where it has grown strongly (42–44). Initial economic evaluation (45) showed that incremental benefit for each patient corresponded to $AUD 16,000 over an 18-month period. The 2020 frontiers special issue devoted to chronic disease and aging (46, 47) built on other work concerning Chronic Disease Management (CDM) programs (48). The Club program trains public health practitioners and clinicians to prevent and manage chronic conditions using Motivational Interviewing (MI) principles (49).

The Happy Life Club coach training program has been (50–52) studied as the subject of evaluations and the program was the subject of a large Randomized Controlled Trial (53) and is a World Bank recommended intervention (54). While MI is a central part of the program, rigorous outcome measurement using validated tools and patient-centered care principles are also key components. These techniques are more broadly applicable across a range of chronic diseases including mental health and addiction disorders (55–57) in controlled trials. It would seem sensible to conduct clinician and public health training so that MI techniques can be more widely applied in public health settings with the aim of further reducing the impact and burden of chronic mental health symptoms.

Digital health platforms: improving population reach and program efficiency

Digital health platforms hold the potential to facilitate Chronic Disease Management across the lifespan at scale in health systems. A large-scale review of digital health platforms was conducted by WHO and the Cochrane Collaboration to develop the Digital Interventions for Health System Strengthening guideline (58). Eleven new Cochrane reviews were included in the guideline. The guideline highlighted different applications of digital health including conventional public health programs, prevention, clinical delivery and back-office programs. It also highlighted the need for the collection of more evidence for these platforms. A 2022 European review (59) investigating the cost-effectiveness of digital health interventions concluded that the evidence was not yet sufficient to return a positive or negative conclusion. We are committed to providing effective digital health support to public health and clinical workers for chronic disease prevention and intervention programs. The goal is to address the knowledge as to how such tools may be best applied (60–63).

Of course, as noted, it is important to be mindful that specific tools are needed for specific purposes and generalizing across all tools is of limited value. Examples of recent digital tool development work in the field of alcohol use include a tool that can estimate weekly alcohol intake based on responses to the extended AUDIT questionnaire; and a web-app brief intervention to raise awareness about the impact of alcohol on breast cancer in a breast cancer clinic setting (potentially modifiable risk factors account for around 25% of breast cancer cases (64, 65)). Another example is that in work led by UK members of our group, we have developed and are piloting a digital tool for NHS gambling treatment services, which collects validated assessment and outcome data from affected individuals and generates readily interpretable summary reports, which are then discussed by the clinician and their patient. This approach could have potential advantages in terms of streamlining the clinical assessment process, fostering early and sustained patient engagement, and improving quality and volume of research data to improve care pathways.

Overall, digital tools are at different levels of development and only some could be deemed sufficiently validated for current widespread use. However, we feel these examples highlight the potential utility of such tools for public health prevention and interventions, in the management and mitigation of chronic diseases. Smart technologies are now available with much-improved access. Recent data shows that access to the Internet of Things will grow from 15 billion to 30 billion devices in the next 7 years (66). Eight billion of these devices will be smartphone connections (67). It is well understood that the availability of smart devices has been less among economically disadvantaged groups. However, this is not cause to deny the obvious advantages of using smart device technologies in global prevention and management of chronic disease of the majority of people.

The importance of rigorous evaluation and validation of approaches to chronic disease management and prevention

As previously stated, there is significant evidence for the efficacy of polygenic and multifactorial risk screening, strong evidence for the efficacy of advanced behavior change principles and a developing evidence base for the efficacy of digital health platforms for some conditions and populations (68–70). Rigorous evaluation of the impact of these approaches in combination and their efficacy across varied populations and chronic diseases and disorders is required. The systematic reviews that have been done of the cost-effectiveness of programs to address chronic diseases show significant advantages (71) but many studies do not include adequate economic analysis or active comparator/control conditions.

The conduct of health economics modeling is a key plank of the valuation of chronic disease management programs. Using tools such as the EuroQoL suite and the use of look up tables developed from major studies credible Disability Adjusted Life Years (DALY) and Quality Adjusted Life Years (QALY) estimations can be constructed from the data (72).

There is the technical issue of what methods of economic evaluation ought to be used to assess the costs and benefits of the study outcomes based on the collected data (73). Many studies use an ICER (incremental cost-effectiveness ratio) or an INMB (incremental net monetary benefit) of the intervention compared with usual programs. Both ICER and INMB methods have limitations, but ICER is currently more widely used. INMB has some appealing aspects. A key one is that it is couched in terms of dollar values whereby costs and benefits are expressed in the same dollar value units. This provides not only ease of interpretation but also the ability to use it to enable direct comparison across different programs. All studies in the program will conform to the design principles outlined in the Bias in Economic Evaluation (ECOBIAS) standards (74) and Consolidated Health Economic Evaluating Reporting Standards (CHEERS) (75) to guide the reporting of study outcomes and rigorous design.

Summary of the suggested multidisciplinary population chronic disease prevention and management approach INTEGRATE

The following chart outlines the logic of the INTEGRATE program approach that aims to enhance improved health outcomes across the lifespan through, prevention, earlier detection and more effective intervention. It is intended that the INTEGRATE model will be applied to a range of chronic physical and mental health conditions at a population level, reflecting the high degree of multi-morbidity identified in population and clinical studies. The INTEGRATE model does not replace guidelines-driven programs and interventions. It provides an organizing framework for important strategic disease risk prediction data based on genomics science and multi-factorial risk assessment, supports public health workers and clinicians using their disciplinary evidence-based prevention/ treatment guidelines to deal with a range of chronic illnesses by enhancing their behavior change skills and assists with the cost-effective delivery of treatment by utilizing advanced digital health platform capabilities. The public health and clinical workers are augmented by powerful support tools (Figure 1).

The INTEGRATE model seeks to combine polygenic genomic and diagnostic testing and history data for target chronic illnesses to identify sub-populations that are low risk, at risk and with diagnosed and undiagnosed conditions. Those with high risk but no diagnosed condition are referred for preventive actions to lower their risk. Those with diagnosed conditions are referred into treatment programs to improve health and wellbeing. All cases in the preventive and treatment programs may be tracked to assess their ongoing health status and wellbeing. These program actions are powered by behavior change science and prevention and treatment guidelines pertinent to their chronic illnesses assisted by digital platform technologies. It is intended that cases and at-risk community members will be detected and enter earlier preventive and treatment programs. Health economics, participant experience and health outcomes studies will be used to evaluate program effectiveness and efficacy. It is intended that health care costs will be lowered, risk reduced, and outcomes improved by the application of this model through its integration into public health and clinical programs targeting chronic diseases.

We have now set ourselves the task of evaluating the efficiency and effectiveness of the INTEGRATE approach we have described for integrated prevention and effective interventions across a range of chronic diseases. We believe that this approach addresses several key problems. Although there have been many exhortations of the virtues of prevention and early invention among at-risk populations, the genomic technologies that practically and expediently this approach are recent, but in some cases are now sufficiently developed to trial and use at scale. However, we must take an evidence-based and skeptical approach using health economics and rigorous clinical efficacy evidence including appropriate control conditions (where feasible). Behavior change science has been with us for several decades, but its power has not been fully implemented due to lack of contemporary training throughout the public health and clinical workforces. This science does not replace, for example, pharmacological and other interventions, it complements and augments them.

We feel these promising technologies are within our grasp and now we have the duty of evaluating and implementing them in an effective integrated way to advantage the targeted populations within our communities. This integrated approach has considerable promise for promoting population health, healthy aging and reducing the current burdens of health care. We also have a commitment to not artificially separate "physical" and "mental" health conditions in a context where they are so demonstrably interdependent.

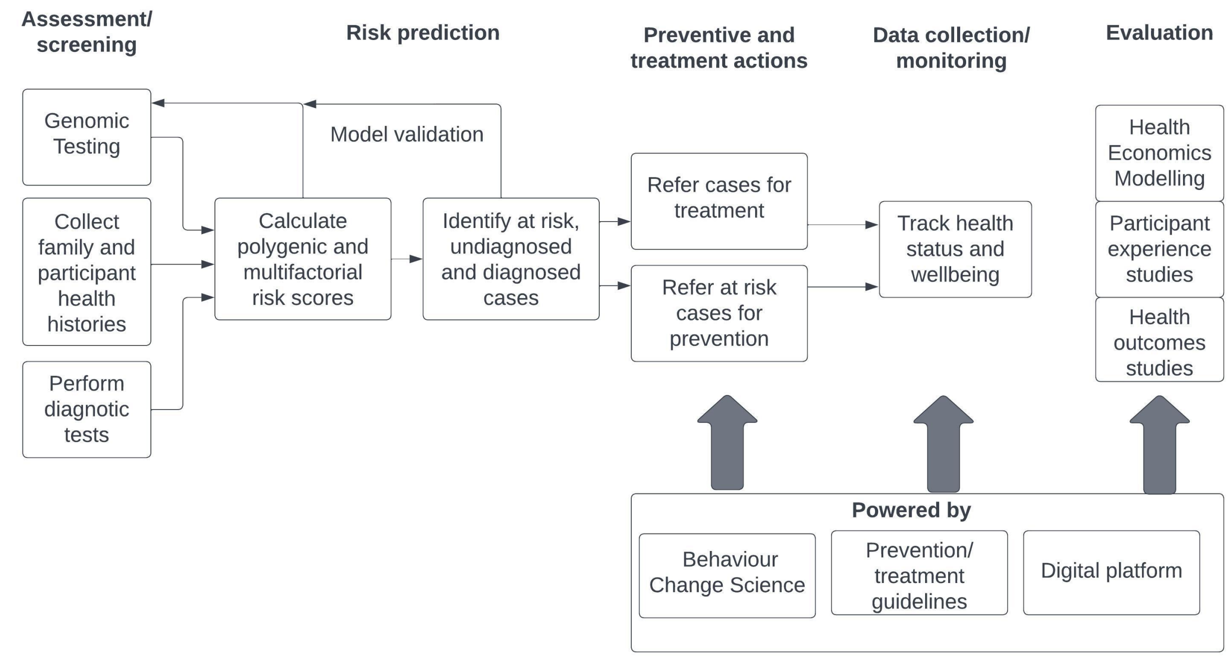

FIGURE 1
INTEGRATE program logic map.

Data availability statement

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

Author contributions

ST and CB conceptualized the paper. ST drafted the paper and had final editorial approval. CB assisted with the drafting of the paper and provided editorial input. FC contributed to the genomic sections of the paper. BK contributed to the digital health sections of the paper. MO provided a public health perspective to the drafting of the paper. HB-J and SC assisted with drafting of the mental health sections of the paper. All authors provided editorial comments in addition to their substantive contributions.

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Conflict of interest

SRC's research is funded by the NHS and was previously funded by Wellcome (an independent charity). SRC receives a stipend for editorial work at Elsevier journals (Comprehensive Psychiatry, and Neuroscience & Biobehavioral Reviews). HB-J is the Director of the UK National Problem Gambling Clinic and the UK National Centre for Gaming Disorders which are now fully funded by the NHS. These clinics have previously received funding from NHS England, Central and North West London NHS Trust, and GambleAware. HB-J is Vice President of the Royal Society of Medicine and sits on several national and international Boards. HB-J has been on research teams funded by the Medical Research Council, the Wellcome Trust, and the Wolfson Family Trust.

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

Publisher's note

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OPINION
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From Precision Medicine to Precision Convergence for Multilevel Resilience—The Aging Brain and Its Social Isolation

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INTRODUCTION

Much like an engineering stress test, the successive waves of the COVID-19 pandemic have highlighted critical pressure points in our already distressed healthcare systems. Physical and mental health challenges continue to accumulate in non-infected persons (1) as well as in those suffering from long-lasting effects of the disease (2). Meanwhile, the implementation of physical distancing containment measures and the significant overload of healthcare systems have resulted in a drastic disruption of elective treatments for most chronic physical and mental diseases.

The pandemic has also emphasized the importance of precision medicine, a convergence between clinical, genomics, and computational sciences (3). A silver lining to this global crisis is the unique combination of precision medicine advances and an unprecedented collaboration between science, business, and society behind the rapid development of COVID-19 vaccines. In this *Opinion*, we argue that lessons from the COVID-19 vaccine response can inform our approach to other equally pressing health emergencies worldwide, such as the epidemic of loneliness in older adults.

We propose *precision convergence* as an approach to achieve this level of synergy in finding societal-scale real-world solutions for a resilient and healthier future, with health and healthcare systems at its core. Precision convergence extends and bridges the scientifically defined multi-scale mechanisms in biology and neuroscience on the one hand and social systems impacting *real-world behavior*, on the other. In this paper, we first elaborate on multi-level resilience and its links to precision convergence. We use social isolation among seniors as an exemplar, or test case, of how and why a precision convergence approach is necessary to potentiate transformative change.

PRECISION CONVERGENCE FOR MULTI-LEVEL RESILIENCE

Resilience refers to "the capacity of a system to tolerate disturbances while retaining its structure and function" (4). By *multilevel resilience,* we refer to the capacity, at every level of human endeavor—from individuals to professions, organizations and institutions of science and society at large—to adapt, evolve and grow in the face of challenging conditions and turbulent change that now define modern contexts.

The speed of cultural evolution that marked the last two centuries is of a different geographical and temporal scale than biological evolution (5). Ironically, advances in economic wealth, social wellbeing, and public health interventions, have brought new challenges to human biology: with extended lifespans come chronic diseases, whereas food abundance and automation are associated with increasing obesity rates. In this context, individual choices are simultaneously conditioned by and powerful drivers of a system-level transformation in economy and society. Since these levels are interlocked, with each level entailing its own multiscale mechanisms, it is essential to understand the dynamics of such interactions as they evolve over a person's lifespan to inform decision making in the pursuit of a multilevel resilience that is not reducible to the sum of its parts (**Figure 1A**).

Multi-level resilience starts with the individual by *adaptive real-world behavior*, with everyday experience and behavior that support health and wellbeing in all dimensions (e.g., physical, psychological, social, cognitive, financial), while accounting for the diverse and dynamic roles and contexts along the lifespan. These are emergent properties of neurobiological systems that underlie one's reflexes, impulses, emotions, and cognitions, which are continuously weighted and re-weighted for adaptive behavior that ultimately guide resilience at an individual level (8). A closely related construct is that of cognitive reserve, defined as "the adaptability of cognitive processes that helps to explain differential susceptibility of cognitive abilities or day-to-day function to brain aging, pathology, or insult" (9). In this sense individual-level resilience stems from and in turn shapes a person's own life experience through the lifelong cumulation of risk and protective factors (10). From this perspective, understanding the human-defining features of brain and mind is a key lever for adaptive, real-world behavior in response to the environmental context created by the economy and society. The COVID-19 pandemic may have fostered resilience at an individual level by forcing a better balance between goals, aspirations, expectations, and achievement of individuals in our roles as parents, citizens, workers or patients vis-à-vis consumer roles, shifting in favor of a more value-driven and meaningful life.

Resilience at the level of professions, organizations, and institutions requires decision makers to be risk-aware, flexible, and agile for real-time and long-term performance. Strategies to reach economy- and society-level resilience have yet to fully create *adaptive* real-world contexts for individuals. Cross-disciplinary and cross-sectoral action focused on target domains of behavioral change and ecosystem transformation are needed, positioning the person at the center of this complex adaptive system of systems in constant evolution (**Figure 1B**). Better accounting for complex and dynamic multi-scale interdependencies is at the core of multi-level resilience and precision convergence.

Precision Convergence is an integrative governance framework that embeds ethical, social and privacy concerns into science, technology, innovation, and policy. Propelled by the digitization of science and society, the vision of precision convergence is to weave next generation biomedical sciences, technologies, processes, and devices needed for real-world solutions in specific domains. Its purpose is to reimagine research, technology, innovation, and policies that better support multi-scale resilience in our transforming world, motivating circular linkages between science and action to *innovate the way we innovate*. This requires a person-in-system approach with a digital-powered and human-centered focus on individual and system-level solutions (11), while acknowledging the challenges and possibilities tied to the multiscale (temporal, spatial or socio-political) mechanisms operating within and across levels in creating adaptive real-world contexts.

SOCIAL ISOLATION AND THE AGING BRAIN: A TEST-CASE FOR PRECISION CONVERGENCE

Protective lifestyle factors that may contribute to increased individual resilience and cognitive reserve include physical exercise, education, and engaging in cognitive and social activities (12), with a recent meta-analysis showing that social isolation was associated with impaired late-life cognitive function (13). As people grow older, their social network typically becomes smaller and oftentimes also weaker (14), with dramatic consequences for individual resilience by impacting brain and physical health (15, 16). This necessary source of interpersonal stimulation has been severely disrupted throughout the COVID-19 pandemic, with a significant weakening or complete loss of social connections within communities. In recognition of the magnitude of this issue pre-COVID-19, the World Health Organization have declared an epidemic of loneliness and the UK have appointed a "Minister of Loneliness" and initiated a campaign encompassing 600 national, regional, and local organizations to reduce loneliness in later life. More recently, Japan followed suit in appointing a Minister of Loneliness to tackle heightened suicide rates linked to COVID-19. Translating these into real-world transformation engaged multiple professions, organizations, and institutions in health and other sectors.

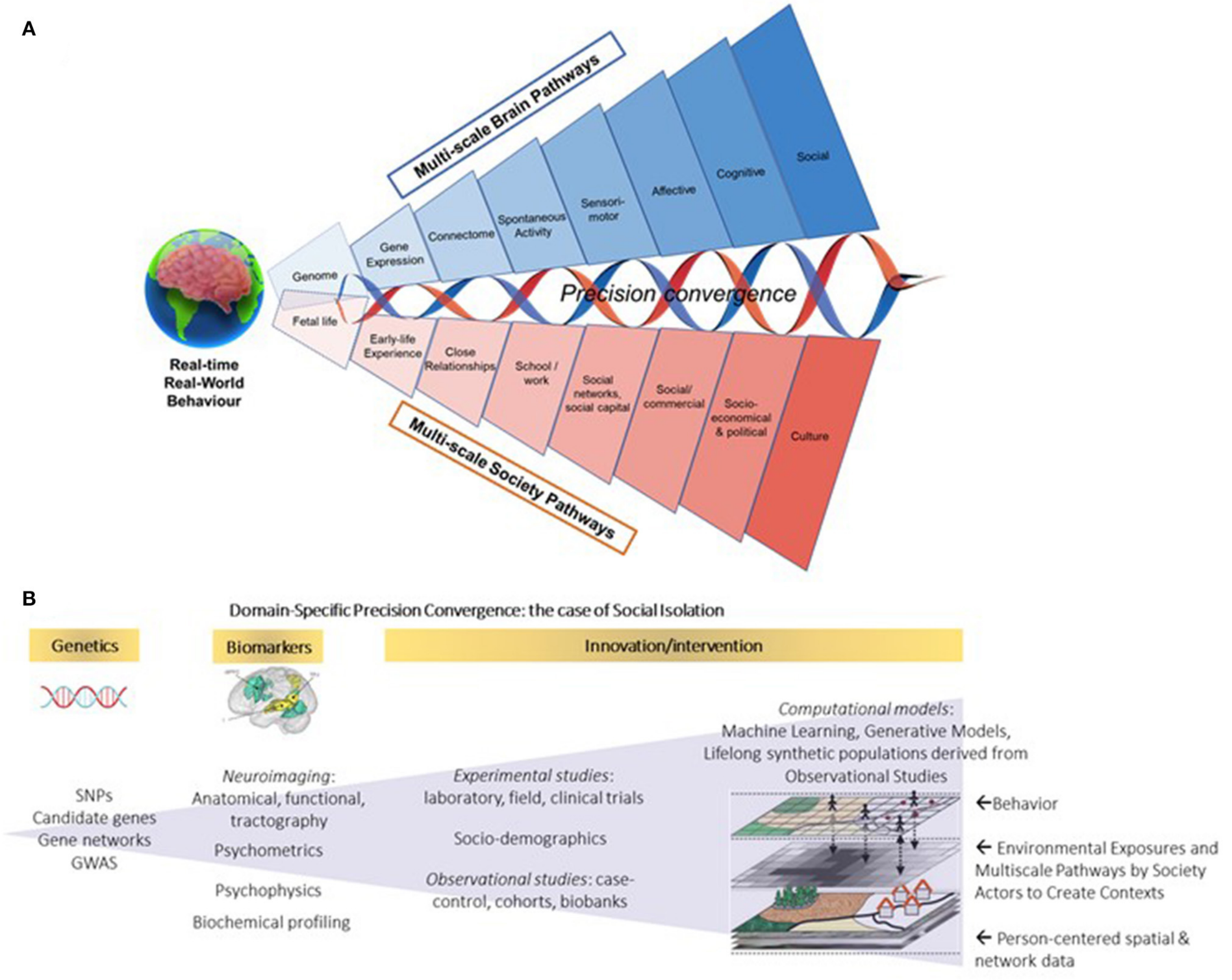

FIGURE 1 | (A) Brain-to-Society (BtS) model of real-world behavior: lifelong achievement, wellbeing, and resilience. Real-world behavior is adaptive, responding to the demands of a changing environment in health and disease. **(B)** Domain-specific precision convergence for social isolation. By integrating multimodal data (e.g., genetics, environment, biometrics) from animal models, experimental studies and population-level research, Precision Convergence aims to strengthen circular linkages between science and action to innovate the way we innovate and inform real-world adaptive solutions toward building multi-level resilience. This figure has been designed in part using resources from Freepik.com (studiogstock, freepik, macrovector), with adaptations from Yang et al. (6) and Spreng et al. (7).

Another concurrent development is our increased ability to gather, structure, and analyze more significant quantities of data with greater efficiency than ever. Propelled by artificial intelligence, big-sample datasets on microanatomy, multi-scale synaptic connections, optogenetic brain-behavior assays, and high-level cognition, research in neurosciences has transformed our understanding of adaptive real-time decisions and behavior (17).

Combined with the digital transformation of science and society, it is possible to support solution-oriented science, technology, innovation, and policy, enabling multiscale-resilience. Consider, for instance, the UK Biobank, the premier "big data" resource that links genotyping, phenotyping and contextual information on ∼500,000 individuals, making it possible to overcome this unbridgeable brain-to-society gap. This is now enabling researchers to investigate complex gene-by-environment interactions underpinning individual differences in brain structure and cognitive processes to better understand and predict health/disease pathways and societal-level behaviors. A recent example of this is our investigations of key brain networks underlying sociality (15) and their functional and structural shifts that are associated with perceived social isolation (7, 16). These studies have enhanced our understanding of how the structure and function of the human brain has led to the evolution of humans as the "ultimate social animal."

These developments in societal structures, policy and technology allow us to investigate social isolation through the lens of precision convergence, building on fundamental research findings in animal models, from gene regulation to the neurophysiological and anatomical correlates of social isolation to building synthetic simulations of environmental factors (**Figure 1B**). Considering that the relative contribution of genetics and/or social determinants of health may vary across the lifespan, Precision Convergence recognizes the diversity of biological predispositions and psychological trajectories in terms of experiences and contexts in the elderly. That, in turn, influences how social network disruptions affect brain structure and function, and how such disruptions influence society. By integrating real-world data across studies (e.g., discovery cohorts, biobanks), currently available and continuously improving computational models can be used to derive representative synthetic populations and develop simulations to test *in silico* policy interventions to support resilience across all levels of society.

PRECISION CONVERGENCE AND MEDICINE IN ACTION

Throughout the COVID-19 pandemic, the lack of resilience in global healthcare systems has been laid bare and we argue that this stems from a lack of convergence between health and other sectors of society. Countries around the world cannot afford to sustain the current tertiary-centered health care system where research and operational investments have resulted in shrinking budgets for primary care or public health initiatives.

Primary care is often a critical intermediary between medicine, public health, and other agents in the community, thereby contextualizing patient needs against the sociocultural backdrop of the world in which they live. This exemplifies the benefits of a precision convergence-guided approach. The personalization of medicine—unique to primary care—rests on an intimate understanding of a community's social and cultural fabric. Given that COVID-19 is impacting people and communities differently, these defining characteristics of primary care need to be supported and strengthened, transforming front line providers into catalysts for change throughout society. This may be achieved by applying Precision Convergence to the evolution of primary care to encompass a team-based approach providing support in all relevant domains: physical, psychological, cognitive, social, and financial. This is already being implemented through the concept of "social prescription" where primary physicians refer patients to community-based support entities (18).

The importance of primary care in improving resilience cannot be understated, serving as a bridge between science and action by individuals, health systems and society. Case in point, obesity, diabetes and heart conditions are established risk factors for developing complications from COVID-19 infections (19). Therefore, improving the metabolic health of populations may assist in building resilience against future infectious disease outbreaks. Moving forward, applying the person-centered approach at the core of Precision Convergence will be essential in reshaping healthier environments. Further, technology-enabled care that the pandemic has forced to the forefront of primary care can help manage routine care by embedding innovations into everyday life as seen with virtual clinical visits.

The accelerated adoption of telehealth, however, has highlighted deficits in our digital infrastructure (20). Increasing accessibility to hardware, software and internet to patients and clinicians alike is important for equitable access in preparation for future public health emergencies (21). Not only will this have implications for access to technology-enabled care, but it also has important repercussions for employment, social cohesion, education, and the environment. This will be critical to a human-centered, digitally powered approach to support health and a recovering economy, including safety monitoring, adherence to vaccination schedules, and tracking population-level vaccination and immunity rates.

Finally, it is necessary to rethink the training of our health care workforce, researchers, policy makers as well as others in all the related domains linked in a convergence approach that is anchored in complexity science and person-centered societal transformation. Going forward, a stronger orientation toward primary care and a precision convergence approach may prove useful in strengthening our healthcare systems to heal from the COVID-19 pandemic and to withstand the impacts of the next global health crisis.

CONCLUSION

Precision convergence builds on longstanding recommendations for human-centered convergence between biomedical sciences (3), policy and action in social, health, and economic domains (22) as well as on more recent calls for solution-oriented social (23) and computational social sciences (24). Our species has reached its current state by adapting to ever more complex group dynamics in families, communities, nations, as well as social institutions and globe-spanning digital communities. The time may be ripe to change the way science and society have operated for centuries. This will require working toward a new era of multi-level resilience that better accounts for interdependencies and connections between individual real-world behaviors and population-level environmental, social, and economic contexts. We believe that harnessing multi-level resilience is possible in a post COVID-19 world and that precision convergence with health sciences at its core can and must be catalysts of such transformation.

AUTHOR CONTRIBUTIONS

LD: conceptualization and project administration. LD, JC-F, GK, and GN: visualization. LD, JC-F, GK, GN, and DB: writing—original draft. LD, PS, DN, SM, CP, JC-F, GK, BK, YM, MK, GB-E, AE, LF, JA, RS, J-YN, SB, GN, and DB: writing—review and editing. All authors contributed to the article and approved the submitted version.

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Health equity innovation in precision medicine: Current challenges and future directions

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Introduction

Health equity is a global concern in health care. While a US Healthy People 2030 goal is to make health care more accessible to Americans, major gaps remain based on socioeconomic status, race, ethnicity, and geography (1). Whether equity challenges will increase or ameliorate as personalized medicine and genomics usher in a new wave of diagnostics and treatments remains unknown (2). A recent Health Equity Innovation Summit on Future Directions in Personalized Medicine, Genomics, and Clinical Care hosted by Texas A&M Health (https://www.healthequityinnovation.org/) explored this landscape—its challenges and solutions. Featuring healthcare expert panels and speakers that included patient groups, care providers, policymakers, technology companies, and academics, the Innovation Summit discussed policy and practice actions to build networks and collaborations. Recurring themes in the Summit addressed determinates of healthcare, including access to clinical trials and cutting-edge treatments. The Summit discussants provided a framework to inform future directions in precision medicine, genomics, clinical research, and healthy aging –and the policies that can impede or catalyze these critical dimensions of healthcare. Voice of the Patient strategies were discussed as a means for providers and investigators to appreciate nuance in niche populations generally, and for these populations to appreciate their opportunity in improving data driven healthcare models and their own health (3).

The promises and challenges of precision medicine

The field of precision medicine has long been considered the future of healthcare. Introduced in 2011 as biomedical research, the field gained exponential exposure and praise, leading to the creation of the Precision Medicine Initiative in 2015 under the Obama administration with a $215 million investment in the nation's 2016 Budget (4, 5). Rather than the traditional one-size fits all approach to managing disease, precision medicine harnesses the power of big data and advances in biotechnology to generate more precise ways of treating disease. Through the partnered use of precision medicine and genomics, some treatments have showcased a reduction of mortality and morbidity in millions of patients with conditions, such as familial hypercholesterolemia, oncology, and psychiatric disorders. Overall, the field has paved its way through new discoveries, FDA-approved treatments, and risk stratification paradigms (6). The tools of precision medicine and predictive data sciences are crucial to shifts in practice guidelines, including preventative medicine and reimbursement policies, that can fulfill the promise of healthy aging. While many ongoing breakthroughs are geared toward treating disease, the propensity of this field in preventing rather than managing disease remains in its infancy.

Disease prevention across the life course remains the hallmark of health promotion and population health. Unfortunately, underrepresented minority (URM) communities in the US often present with greater risks, and at later stages that predispose community members to diseases and worse health outcomes, respectively. Perpetuated by a myriad of factors, including long-standing mistrust of the healthcare system, geographical distance from care, language barriers, and fear of encountering implicit bias and stereotyping during care, among others, URM communities are often at greater risk for sub-optimal health outcomes. For these populations, traditional medical approaches that focus on the disease incidence and management may produce mixed results—success, no change, or adverse effects following disease incidence— as they fail to account for underlying social, cultural, environmental, and lifestyle factors that contribute to health. Studies have shown that these inconsistent outcomes may also be linked to a low representation of URM in genomic registries and other clinical trials (7). These earlier studies argue that lower rates of clinical trial participation from URM groups shape future treatments so that meaningful treatment options for these communities are unequally distributed (8). This is further concerning as Turner et al. report that about 80 percent of the US clinical trials' pool consists of non-Hispanic white populations suggesting that other population groups might experience fewer benefits from biomedical research due to poor representation and barriers to healthcare access (9, 10).

This has direct implications for the field of precision medicine in that groups less likely to receive precision medicine treatments are racial minority and ethnic groups, medically underserved urban and rural communities, uninsured and underinsured, as well as those with lower education and income (11). More so, while precision medicine commonly uses genomic data for patient treatment plans, genome-wide association studies (GWAS) rarely test the relationship between complex genetic traits and environmental exposure (8). We posit that precision medicine for prevention and treatment holds promise in advancing health, particularly for medically underserved urban and rural groups, many of whom identify as belonging to one or more underrepresented groups and with varying degrees of genetic admixture (e.g., biogeographical ancestry analysis), an area in genomics that remains largely unexplored. Genetic variants of low frequency are likely disproportionately important in disease (12).

Frequent confusion within the field of precision medicine stems from the absence of defined population categories leading to inconsistent misrepresentation or classification of underrepresented communities in clinical trials (13). For example, grouping all racialized groups together often creates challenges with translating study findings into the real-world setting where racialized groups are far from a homogenous population. In recent years, ethnicity determined through genomic analysis has been proposed as a more precise approach to contextualize disparities rather than the social construct of race (14). For example, the use of genetic patterns, including variations of drug metabolism and drug targets, indicates that there are issues in representing human population genetic structures in evaluating drug safety and efficiency and relating this structure to drug response. Commonly used ethnic labels are both insufficient and inaccurate representations of inferred genetic clusters, with the possible result that drug-metabolizing clusters would differ significantly (15). The potential solution to this is increased clinical implementation of pharmacogenomics based on the increased inclusion of underrepresented groups to guide drug therapy.

It is also important to acknowledge and address the contentious relationship between URM and clinical trials as long-term research endeavors often have negative connotations long past their initial purpose. One of the most notable examples for African American communities is the USPHS Syphilis Study at Tuskegee which is often viewed as a major source of healthcare mistrust in the African American community (16). Conducted from 1932 to 1972, this infamous natural history study neglected informed consent, denied available treatment, and produced meager benefits compared to human subjects' benefits. Other remembrances include the role of Dr. J. Marion Sims, the father of gynecology, who performed surgeries on "slave women," experimenting on them without the use of anesthetics to perfect his technique to repair vesicovaginal fistulas. Further, there is collective memory about "night doctors," who would steal cadavers of African American individuals to learn more about human body processes (17). Other studies have reported fear and mistrust in Hispanic communities as contributing to poor patient engagement. For example, Davis et al. (18) reported that Hispanics lacked trust in medical professionals and "feared being a guinea pig," whereas those less educated cited a fear of being embarrassed during cancer screenings. Rodriguez-Madera et al. (19) noted that for Puerto-Ricans, there is a history of mistrust in the government, emanating from resentment over its perceived sense of alienation and "rooted in a longer history of political ineptitude."

Toward community-centered approaches

Trust issues continue to permeate modern-day healthcare. Addressing these barriers requires an understanding of these issues and, in turn, the ability to use that knowledge to develop community-centered approaches to reach these populations. One approach to address this is the Community Health Workers (CHWs) or promotores model, in which lay health workers serve on the frontlines to facilitate access to services through education and connections to social services and resources (20). Within the US healthcare system, CHWs often act as a bridge between a patient's healthcare provider and the patient themselves and work to improve this relationship by tailoring care specifically to the patient's needs in a manner that is culturally competent and appropriate to the patient. This approach improves engagement with its patient-centered responsiveness, rather than a generalized response that often misses its mark (21).

Other community-centered approaches include the use of community champions who are from the community, look like the community, speak the same language as the people in the community, and share relevant contextual experiences. It is also important to engage the community at the beginning of clinical trials and consider their input in the co-design and development of initiatives that will apply to them. For example, the National Institutes of Health has launched the "All of Us" research initiative that includes several innovations to address health equity, including dedicated efforts to reach, engage and retain diverse populations, cover many different geographies and settings, coordinate different data sets, and make community engagement a central outreach approach (22). Similarly, the National Human Genome Research Institute has launched a long-term partnership with Alaskan Native tribes to "overcome logistical and communication barriers in the hope of encouraging their involvement" in clinical research (23).

Continuous engagement creates an atmosphere of transparency which, in turn, builds trust and gives patient agency and fosters the translation of evidence-based practice from "bench to bedside." Processes that can be used to reach this point include ongoing participation in community-led events (in place of one-time partnerships), layperson explanation of precision medicine, and data collection and usage, all while setting clear parameters for compensation, and benefits to the individual and the community. Such efforts can come to fruition through multisectoral collaborations that involve key stakeholders from diverse settings including universities, industry, communities, medical centers, and local, state, and federal governments.

Multisectoral partnerships that foster shared decision making and common goals can lead to innovative solutions like the warp-speed creation of the COVID-19 vaccination programs (24). Again, it is important to differentiate trials from actual vaccine rollouts. A systematic review of prevention and treatment clinical trials for COVID-19 in the US (25) estimated the representation of participants by sex, race, and ethnicity as compared to the US population with COVID-19 during that period. Underrepresented populations were generally underrepresented in these trials with the exception of Hispanics being over-represented in COVID-19 treatment trials. Similarly, initial vaccine uptake rates were dramatically lower in racial and ethnic minority groups although dedicated attention and resources has helped narrow gaps (26, 27).

Discussion

The mission of precision medicine is to provide individualized treatment plans to patients, in part through the integration of advances in technology and genomics. Although precision medicine has been promoted for over a decade, too often the impacts of social determinants on health have been ignored, with patient management delivered in the absence of a clear understanding of the underlying social and cultural context. In addition to minority and ethnic populations being underrepresented in clinical research, older adults have also been characteristically underrepresented in clinical trials (28). To counter age-biases in research, the National Institute of Health now expects inclusion across the lifespan and explicitly require justification for age exclusions in its funded research portfolio (29). But nuance is also called for here, as chronological age categories are often distinct from biological/ functional statuses and have different treatment implications (30).

Hence, while precision medicine has promise, new paradigms are needed to ensure health equity for URM populations, and especially older adults. Everyone has a role to play in the roll-out of precision medicine and the translation of precision medicine into precision prevention. We urge federal and state governments, health care systems, biotechnology and pharma industries, clinicians and academics, patients, and community groups to become informed and to step up to the challenge of making precision medicine relevant to the health and wellbeing of all. This includes proactive steps such as having explicit goals to reduce extant health disparities, greater awareness of the importance of community-centric approaches, consideration of differentiated vs. homogeneous racial and sociodemographic categories, availability of diverse genomic data that is coordinated with a full range of health and social data, and improved provider-patient-community relationships to build needed trust in the health care system and the benefits of clinical research.

Author contributions

MGO, OEA, KSR, PSS, and DVD helped to conceptualize the manuscript and provided a framework for furthering research at the intersection of health equity and precision medicine. MGO and OEA prepared first draft. KSR, PSS, and DVD added specific perspectives on precision medicine and genomics. All authors assisted in drafting the manuscript and reviewed and approved the manuscript.

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Conflict of interest

DVD was employed by DVD Associates, LLC.

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Social Technology: An Interdisciplinary Approach to Improving Care for Older Adults

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Population aging is a defining demographic reality of our era. It is associated with an increase in the societal burden of delivering care to older adults with chronic conditions or frailty. How to integrate global population aging and technology development to help address the growing demands for care facing many aging societies is both a challenge and an opportunity for innovation. We propose a social technology approach that promotes use of technologies to assist individuals, families, and communities to cope more effectively with the disabilities of older adults who can no longer live independently due to dementia, serious mental illness, and multiple chronic health problems. The main contributions of the social technology approach include: (1) fostering multidisciplinary collaboration among social scientists, engineers, and healthcare experts; (2) including ethical and humanistic standards in creating and evaluating innovations; (3) improving social systems through working with those who deliver, manage, and design older adult care services; (4) promoting social justice through social policy research and innovation, particularly for disadvantaged groups; (5) fostering social integration by creating age-friendly and intergenerational programs; and (6) seeking global benefit by identifying and generalizing best practices. As an emergent, experimental approach, social technology requires systematic evaluation in an iterative process to refine its relevance and uses in different local settings. By linking technological interventions to the social and cultural systems of older people, we aim to help technological advances become an organic part of the complex social world that supports and sustains care delivery to older adults in need.

Keywords: technology, social system, interdisciplinary, social integration, care, older adult

SOCIAL TECHNOLOGY: AN INTERDISCIPLINARY APPROACH TO IMPROVING CARE FOR OLDER ADULTS

Despite global volatility in economic, political, and health domains, two megatrends have persisted over recent years. One is population aging, which is becoming a global experience affecting virtually every nation in the world, with East and Southeast Asia undergoing the fastest increases (1). The demographic trend of aging, accompanied by increases in demands for care and by a continuous decrease in the numbers of working-age adults in most countries who can support older people, poses a serious threat to civil societies that seek to manage resources to meet the growing need for care. The other trend is the growth in the digital technology industry and an enduring belief in the need for technology among older people. Baby boomers indicate increasingly that their preference is to age in place at home. Equally clear is their hope to use technology to increase their ability to live independently (2).

The challenge is integrating these two mega trends so that each benefits. That is, technology can provide means to reduce the burden of care and increase quality of life for older adults and their caregivers, and the needs of the aging population can in turn stimulate targeted technology development and contribute to the much-expected arrival of a "silver economy"—an economic transformation that makes better use of older people's skills and knowledge and thereby contributes to a more availing future for them. To facilitate this integration, we have developed a research program based on an approach that we term *social technology*.

What do we mean by social technology? We begin by specifying what we do not mean. We do not mean to imply social engineering activities, such as implementing a centralized plan such as government-organized care practices that are the same for everyone in an effort to engineer people's lives (3). We are also not supporting the development of technologies for top-down social control through surveillance and security monitoring systems. And we definitely do not mean simply finding new ways to convince older people that they should accept a particular technological innovation.

Far from that, we aspire to integrate social science and engineering approaches in interdisciplinary methods that extend from planning through innovation, testing, and outcome assessment. We recognize that aging in this century is a challenge to systems that only systems' solutions can address through careful analysis and integration. We aim to build social technologies through a deliberate process of selection, development, and integration in various social and cultural settings. The goal is to create unique solutions that will assist individuals, families, and communities in coping more effectively with the disabilities of older persons by mitigating functional limitations caused by frailty and other sources of mobility problems that typically lead to isolation, cognitive decline, and depression. We will also address problems related to sensory losses, dementia, and mental illnesses, recognizing that these problems often overlap. We believe that social technologies can help reduce the burden on families and organizations that provide care to older adults who can no longer live independently.

Developing and identifying socially and culturally appropriate technological solutions to improve care for older persons with frailty and dementia is important; equally critical is integrating technology with social systems designed for the delivery of care—a complex process typically involving social, cultural, and ethical considerations. Effective social technology requires research efforts to integrate technological innovation with complex social systems to improve the quality of care and reduce the burden of caregiving for older people. Although the details of the social technologies have yet to be fully developed, we bring to this activity particular orientations and aspirations. Our vison is that, in practice, social technology would include these six specific considerations:

Fostering Multidisciplinary Collaboration

Social technology starts with a comprehensive evaluation and understanding of problem scenarios and of many factors that potentially determine outcomes. By taking a biopsychosocial environmental perspective that acknowledges the complexity of human interactions within physical, social, and cultural contexts, we encourage multidisciplinary collaboration among social scientists (e.g., anthropologists, sociologists, psychologists, economists), engineers of different disciplines, and medical and public health researchers to maintain integrated views that are neither reductionistic nor inhuman. Multidisciplinary teams are essential to address older persons' needs. By using ethnography and other field research methods, we promote a bottom-up approach in which social scientists actively collect extensive information to understand the needs and living scenarios of older people, and their cultural and historical contexts, to guide the development of technological innovation or technology-based service innovation. The interactions and conversations among engineers and social scientists will optimize solutions and create new knowledge and innovations that are tailored appropriately. The policy framework within which care takes place will then increasingly tie together priorities, funding, and the local network of social services to health administration.

Including Ethical and Humanistic Standards in Evaluation of Innovation

The value of an innovative solution to a care problem should be measured not by whether the technology employed departs from a previous technological method, but by how much the innovation improves the quality of care or its delivery and how compatible it is with local ethical standards and humanistic concerns. We particularly stress the importance of considering the perspectives of older persons and their families, emphasizing their desire for dignity and respect. Involving patients and family caregivers in this knowledge-generating process will be a conscious commitment, so that their input can help us create, modify, and improve social technology applications and prevent unintended negative consequences. This will also ensure the vital integration of cultural values and social requirements of the particular settings in all solutions. Moreover, we will encourage researchers to move away from being dispassionate experts and actively engage in the practice of care for others, making it "indispensable to the pursuit of social understanding" (4). The emotional and moral involvement of engineers will develop the appropriate appreciation of and thus sensitivity to older adults' needs and will enable innovations that serve that cause. Such social care, then, becomes integral to the research and to its outcome.

Improving Social Systems

According to the social ecological model of care (5), older adult care is an integrated system that is ideally provided, supported, and sustained by stakeholders across several layers of a social system. These stakeholders typically include family caregivers who are usually the mainstay of care provided to older adults. Professional home care support programs, community-based daycare and exercise programs, long-term care facilities that provide an alternative to home care for older adults, and larger social policy agencies (e.g., insurance policy and housing policy agencies) that ensure sustainability of care are other parts of the system. We are committed to identifying and developing technological solutions that will be organically integrated within the care system and will assist, equip, strengthen, and honor family caregivers and other direct care workers. We will collaborate closely with those who deliver or manage care for older adults (e.g., nurses, physicians, pharmacists, physical and occupational therapists, psychotherapists, social workers, public health experts, economists, health and social service designers, and business executives) to improve service designs, perform feasibility testing, and optimize the use of supporting resources across physical and social distance. Social technologies will strengthen and integrate often fragmented care delivery systems. In some cases, a new social infrastructure (e.g., a community-based rehab device rental center) may need to be developed and/or additional training of personnel provided to facilitate and expedite the dissemination and diffusion of innovation.

Promoting Social Justice Through Policy Research and Innovation

While aiming to bring technological solutions to most older adults, ensuring that socially disadvantaged groups be included as beneficiaries of technological solutions is critical. Special effort will be exerted in selecting and redesigning technologies toward a lower price range, so that ordinary people living in lower resource and marginal communities can afford them. We will collaborate closely with policy researchers and policy makers to explore social welfare policy innovations that will make technological solutions available for poor, marginal, and voiceless groups such as those in some disadvantaged rural areas or those with limited general and digital literacy.

Fostering Social Integration

Among many benefits and impacts those technologies may bring to older adults, we particularly hope that technologies can contribute to socially cohesive and integrated societies. This means that technological solutions will help older persons increase their sense of social connection and reduce their feeling of loneliness and isolation. It could also mean that technologies will enable older people, in their post-retirement years, to attain their optimal functioning level so that they can continue to participate in social, learning, caregiving, and economic activities while maintaining and managing their physical and mental health. We envision that the available advancements in digital technologies, such as artificial intelligence and new imaging modalities, will be tailored to become part of social technologies and contribute to this vision. Similarly, technologies should increase opportunities for creating a truly intergenerational and age-friendly society in which active aging is an option and images of older persons as life-long learners and contributors gradually become part of a new social norm replacing the old prejudice of aging being associated with decline, deficiency, and dependency. Here social technology will contribute to reducing negative stereotypes and stigma.

Seeking Global Benefit Through Best Practices

We hope that these solutions that combine technology with social science and sensitivity to cultural values will not only be useful in one location or one country but can also become generalized and applied in settings in many nations that also face the challenges of population aging and associated care challenges. By identifying and studying best practices of social technology that have been implemented in real-world settings, have also been evaluated systematically to obtain evidence of benefit, and are well-documented to improve transferability, we hope to contribute to the global effort to cope with the rapid growth of older adults' care needs and thereby strengthen the field of global aging.

Final Thought

We treat social technology as emergent and experimental and as requiring systematic, iterative evaluation that refines its relevance and use in different local settings. We recognize that some of the concepts included in the social technology approach may have a history [e.g., (6, 7)]. Other concepts, such as gerontechnology and quality of life technology, may seem similar to social technology. Given that the emphasis in social technology is on the planning, community embeddedness, interpersonal and institutional consequences, and societal uses (and misuses) of technology, we view social technology as a system concept that includes gerontechnology and quality of life technology within its framework. By employing multidisciplinary collaboration and ethical/humanistic standards, we hope to enhance the process of innovation, and by emphasizing the importance of broader social benefits of technological solutions through improving care service, social justice, and social integration, we believe that this unified systems approach will help build a future society where intention and quality of care are more valued than efficiency and economic performance indicators.

Technologies will evolve as new inventions and innovations are developed and modified appropriately based on findings from social science investigations. At the same time, we recognize that technology may have unintended consequences. In the domain of healthcare an example is the electronic medical record, which has been criticized for making it more difficult for doctors to focus on patients rather than the computer and deliver more humanistic care (8). Despite this negative example, we still believe that technology has great potential for improving care and caregiving (9). By linking technological advances to the social and cultural systems of real-life of older persons, we aim to help technology become an organic part of the complex, dynamic social system that supports and sustains care delivery to older adults in need. In doing so, we intend to help build communities that are able to connect the benefits of technology to processes of care and that embrace serious concern for well-being and humanity (10).

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

AK, HC, FH, and SL are involved in the development of the idea of social technology and writing of the first draft. All other authors contributed to the elaboration of the concept and its specific significance in China as well as manuscript revision.

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“Researcher” bias: How our assumptions on technology affect research of older adults

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older adults, technology, assumptions, person-centered, bias

Introduction

As researchers, we are comfortable with different aspects of the scientific method: Designing studies, implementing interventions, collecting and analyzing data, and synthesizing results. We progress in our careers, solidifying our skills and potentially, our assumptions.

Assumptions are human. Assumptions are heuristics that allow us to more efficiently operate within our natural world (1). However, if we do not actively engage with and question our assumptions, we become comfortable with our own biases.

For those with careers in the field of gerontology, we have undoubtedly heard comments like, “You won’t get good data by doing interviews with older adults over the phone.” or “Older adults will not participate in research if it involves technology.” These assumptions—that older adults cannot operate technology or cannot answer questions over the phone or on Zoom—reflect not only ageism but a scientific bias (2).

Yet, comfort with technology exists on a spectrum (3, 4). We know that many older adults are comfortable with technology, such as smartphones and tablets (5). Adoption of technology has accelerated, particularly due to the COVID-19 pandemic. One study found using data from the National Health and Aging Trends Study reported that older adults were engaging in more technology-based activity and technology-based health communication (6). At the same time, we also know that nearly 22 million older adults in the United States lack broadband access in their home (7).

While our assumptions about older adults and technology may be based in reality, we risk limiting ourselves and our research if we let our assumptions take the reins.

We believe that assumptions regarding older adults and their ability to access and use technology tend to be based on pre-COVID experiences and limit our study designs and approaches. We recommend that researchers consider the needs and abilities of their specific older adult population regarding technology and respond proactively to the specific experiences of their participants.

What we can learn from our participants

It is important as researchers that we do not make assumptions for our participants but instead follow their lead. We can learn from community-based participatory research principles, particularly the collaborative involvement of participants in all phases of the research, to bring the voice of older adults into our research (8). While this sense of openness and flexibility may cause some anxiety, we can ask our participants at various stages of our research about how to meet their needs and improve the quality of our science (9). We share two case studies below representing reflections of our own biases regarding older adult populations and technology and the how our team(s) reframed their thinking.

Case study 1: Older African American women living with pain and low mood

We are conducting a study testing a behavioral, pain-management intervention for older African American women living with pain and low mood. During intervention development, we explored preferences for visit setting. The team assumed that these women would prefer virtual visits, particularly during the COVID-19 pandemic due to safety and health concerns, and would have the capability to access the intervention virtually. Both in-person and virtual options were presented to the participants; so far, of twenty participants, twelve have opted to do in-person visits. When asked why, one participant said that having the nurse come to her house was "rewarding, (especially) when you live alone." Another participant commented that she did not have Internet access in her home and would have been unable to participate in a virtual-only intervention.

Case study 2: Caregivers of persons living with heart failure

In another study we are testing a self-care intervention for caregivers of persons living with heart failure. During a pilot phase of the study, the protocol was written for in-person visits as it was assumed this would provide the easiest and most person-centered means of delivering the intervention: The participant would not have to travel, the nurse interventionist would gain more context to aid with intervention delivery. The team also assumed that older caregivers would not "get as much" from virtual intervention visits. Due to the pandemic, the pilot study went entirely virtual. In an effort to support equitable participation, tablets were provided to all participants. However, all participants had their own technological device, and the tablets, though provided, were not utilized. When asked about the change in modality, participants had no issue using their own technology and preferred the flexibility that virtual meetings had to offer: Virtual visits could be canceled and rescheduled more easily. In fact, the virtual visits were person- and caregiver-centered.

These two stories have commonalities between them. The decisions made during the study design stage were intended to reduce study burden on the participants; however, some assumptions were made regarding the population's ability to access and use technology. Yet the most important takeaway from these case studies is the responsiveness of the researchers. Listening and responding to participant feedback is key to delivering participant-centered research.

We are human

Now, as mentioned above, making assumptions is a natural human response. Often, our assumptions are informed by years of practice and research, previously published literature, and communication with colleagues and peers in our fields. Making assumptions is reasonable. However, by making these assumptions related to technology, do we limit the "presumed" benefit of our research or interventions? Do we limit our potential findings? And do we limit ourselves as researchers in terms of creativity and expansive thought?

Discussion

We propose choices that researchers can make to curb our natural instincts regarding our research and study design (Table 1). As research continues to evolve, let us ask ourselves:

1. Is there flexibility in our protocol? For example, offering in-person and virtual options for intervention delivery and/or data collection. For older adults, in-person visits may be challenging given mobility limitations and transportation options (10, 11); in contrast, virtual visits may be challenging given access and comfort with using technology (3, 7).
2. Are the decisions we are making participant-driven? For example, if our older adult participants have stated preference to a certain modality of intervention delivery and/or data collection, we should be responsive when drafting or revising the protocol (12).
3. Is there opportunity for us to receive feedback? For example, including post-intervention interviews or surveys with older adult participants to ask about intervention delivery and/or data collection modalities (13–15). We want to make their participation "well-worth the effort" (14).

TABLE 1 Our guiding questions and proposed solutions.

Guiding questions	Solutions to our assumptions
Flexibility in protocol & pre-study activities	• Meet with your IRB representative to discuss opportunities for flexibility in your protocol. • Include a community member/member of your population of interest as a member of the study team. • Actively seek to create a diverse study team in terms of gender, race, ethnicity, age, career, etc.
Participant-driven design	• Incorporate elements of human-centered design into your protocol and interventions. • Create a Patient & Family Advisory Council to guide your study team. • Create a community advisory board to guide your study team.
Opportunity for feedback	• Utilize qualitative, quantitative, and/or mixed methods evaluation for richer understanding of your participants' experiences. • Include a participant experience survey or interview after completion of the research. • Use an open-label pilot design prior to the full intervention. • Talk to experts outside of your comfort zone for their thoughts and advice.

It is important to note that our assumptions are not always wrong, and we make them for different reasons: Efficiency, history, etc. But as researchers, we have to constantly question our assumptions, especially those regarding technology and different older adult populations. This active questioning allows us to minimize the "researcher" bias that we may introduce into our studies. We cannot eliminate all bias in our science, but we can continually challenge our assumptions by asking questions and elevating the voice of the older adult communities we serve.

Author contributions

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

Conflict of interest

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Activity-friendly environments for active aging: The physical, social, and technology environments

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Introduction

Leading an active life, both physically and socially, is crucial to maintain health and wellbeing in old age. As defined by the World Health Organization (WHO), "active aging" is "*the process of optimizing opportunities for health, participation, and security in order to enhance the quality of life as people age*" (1). It was first used as a policy concept to steer communities, cities, and countries toward aging-friendly actions, emphasizing an active approach to life and the need for older people to continue their involvement in a range of physical and social activities across different functional domains (2). But this concept was not fully operationalized considering the diverse perspectives of older individuals. To address this limitation, researchers have further developed approaches to measure and understand active aging, which reflect how an older person's actual behavioral decisions are a consequence of balancing one's capacity to move, one's opportunities to participate, and one's goals and preferences toward meaningful activities (3, 4).

Physical environments play a significant role in active aging and may facilitate or hinder opportunities for health, participation, and security. Older people's preference for "aging in place," or the opportunity to continue residing in their current home and community for as long as possible, remains strong (5), further highlighting the need for environments that support active aging. An "activity-friendly environment" should include support from the physical environment as well as socio-cultural and community structures to enable and motivate active aging (6). In 2007, WHO proposed a framework for age-friendly cities containing eight interrelated domains covering the physical, socio-cultural, technological, and service environments (7). Despite its popularity as an original and comprehensive framework, it does not fully consider the heterogeneity of older adults and equity issues, and has limited applications/implications in middle-to-low-income countries (8–11).

In recent years, technology has become increasingly important in our lives, while enabling an active and engaged life in different ways than before. Emerging technologies also offer new tools and methods for researchers to assess both environments and behaviors as related to aging, thus enabling a better understanding of the complex person-environment interactions. However, the digital divide may be most pressing for older age groups, who may not be digitally literate or do not have the means to utilize technologies (12).

We provide expert opinions on how the physical aspects of activity-friendly environments can optimize opportunities for health, participation, and security, and thereby facilitate active aging, and how those are closely intertwined with the social and technology domains of environments. Both housing and neighborhood environments are discussed, and so are emerging trends, methods, and approaches in research and practice related to design for active aging.

Physical environments

The housing environment

Housing is essential for active aging, serving as not only a shelter but also a place of purpose and identity (13). As people age and develop functional limitations, the lack of person-environment fit (3, 14, 15) is often first reflected in housing environments, leading to the need for home modifications or relocation to a different home or a long-term care facility. The types and options of housing available to older people vary by location, and significant gaps often exist between the demand and supply of appropriate housing options.

An individual's housing choice is affected by multiple factors such as availability, housing policies, socio-cultural norms, and personal factors (e.g., finance, health status, and preferences). For example, physical barriers in residential units (e.g., multiple floors with stairs), prevalent in European cities, and traditional single-family zoning, common in the U.S., often force older people to move away from their familiar communities in pursuit of more suitable housing despite their preference for aging-in-place. Spatial segregation of homes suitable for different life stages limits housing options for older adults (16), compromises their opportunities to stay engaged in their communities, and marginalizes intergenerational contacts (9). Recently, in the U.S., some states (e.g., Oregon and California) and municipalities (e.g., City of Minneapolis) have initiated zoning reforms to allow multiple housing types (e.g., apartments, accessory dwelling units) to coexist in the same community (17).

Environmental attributes of senior housing (individual homes or congregate living) can affect seniors' physical activity, social engagement, independence, mobility, security, and aging-in-place. Relevant housing-level factors range from room features to the overall building layout and site plan. Examples include accessibility, assistive features (e.g., handrails), daylighting, window view, indoor-outdoor connections, transitional areas, greeneries, hallways or footpaths for walking, and destinations in or around buildings that can encourage physical/social activities (18–21).

Overall, policy interventions and innovative designs are needed to provide new housing models with more *diverse, supportive, affordable, and adaptable options within the community* that can support active aging and aging-in-place (22). This would require purposeful planning and design considerations in terms of the physical environment such as proximity to community amenities and spatial design balancing privacy and access/connection, as well as active engagement of seniors in the planning and design process to ensure the physical environment reflects their personal goals and preferences. These physical environmental features should also be integrated with supportive programs, social networks, and intelligent technologies in home services and health monitoring and management, to better support active aging (23).

The neighborhood environment

For older adults, especially those with declining physical and cognitive resources, opportunities to participate in physical and social activities may be restricted due to the reasons beyond the individual. Features in the neighborhood environment impact older adults' ability to move about and be physically or socially active. Yet, understanding of the neighborhood as a unit has proven highly challenging. Administrative units (e.g., postal code areas, census boundaries) may not be consistent with personal perceptions of the neighborhood, which vary according to personal capacities and preferences (24, 25). Furthermore, experiences of the environment are highly individualized, as awareness of environmental features depends on exposure to the environment (where one actually uses) as well as one's individual functions (e.g., physical, sensory, and cognitive capacities) and other resources (e.g., financial resources, car availability, social support, and time restraints).

Active aging research also lacks unified definitions and standards for assessing the neighborhood environment (25). The variability of definitions and perspectives suggests the need to study person-environment relationships using multiple data sources (9, 24). Assessing one's individual capacity is a common practice in health sciences, and life-space assessments (environmental exposure) by means of a questionnaire or technologies (26) have gained popularity in the last few decades. However, accounting for multiple personal and environmental resources at once is not a common practice yet, especially not in the aging research field. Acknowledging the complexity of these relationships and the full range of factors involved, moreover, poses theoretical and methodological challenges that need to be tackled.

Despite these challenges, various environmental factors have been consistently identified as correlates of active aging in older adults. For example, physical environment features such as high street connectivity, diversity in services, sufficient infrastructure (e.g., sidewalks, trails, lighting), and availability of green spaces (e.g., parks, nature) have been found to promote physical activities, especially walking, among older adults (27). These serve as a good starting point to characterize the physical environment that supports active aging in place, to design environments conducive of active aging, and to further develop future research.

Social environments

The growing interest in aging-in-place emphasizes the importance of positive and familiar social and physical environments as people age. Social ecological models suggest multiple domains of factors impacting health behaviors such as physical activity and emphasize added importance of social factors for older adults (28, 29). Social engagements are among the key determinants of active aging, and social environments can be either facilitators (e.g., social support, positive social networks, cohesive neighborhood) or barriers (e.g., social isolation, crime risk/exposure, social inequity) to active aging. However, mechanisms through which older adults' exposure and response to these social conditions impact active aging are not fully understood.

Researchers have pointed to the interplay between the physical and social environments (30–33). Some early evidence suggests significant roles of social places like the "Third Places" in the neighborhood, which typically include religious places, food retails and services, recreational destinations, and senior centers (34). However, more efforts are needed to identify the specific types and features of such socially-oriented places important for different groups of older adults, and how and to what extent they influence older adults' physical/social activities as well as aging-in-place. Significant heterogeneity exists across the socio-cultural and economic contexts, and therefore more context-sensitive knowledge is needed to better understand the roles and features of social environments that support active aging.

The concepts and measures of social environment used in the active aging literature are limited. Social factors can be approached from the contextual social environment perspective (e.g., neighborhood cohesion, social capital) or from the ego-centric social network perspective (e.g., size, stability, and strength of social networks/ties). While correlated with each other, these factors have distinctive roles and their specific impacts on active aging outcomes are not fully explored.

The socio-cultural environment is critical in addressing larger societal issues related to population aging, encompassing healthcare cost, caregiving burden, reduced workforce, and intergenerational conflicts. Growing efforts have been made to respond to this demographic shift from a broader policy and community level, such as the Age-Friendly Cities Framework by WHO (35) and various programs offered by Generations United and AARP in the U.S. Still, efforts are needed to better understand the physical and social environmental factors that contribute to supporting active aging across the lifespan and intergenerational interactions.

Technology environments

Technology is increasingly implemented in home and care settings to facilitate interactions, and to support older adults' independence and participation in meaningful activities (36). Remote communication tools or smart monitoring solutions utilizing sensor-based technologies (e.g., passive infrared motion sensors, body-worn sensors, pressure sensors, video monitoring and sound recognition) may help older adults manage daily tasks (e.g., environmental reminders to initiate specific behaviors) and environmental challenges (e.g., long distance to services), and facilitate independent living (37). To prevent unequal access to these services and tools, it is crucial to develop simple and intuitive solutions. This requires participatory research in collaboration with individuals with limited digital skills and businesses willing to invest their time and resources to improve accessibility by diverse end-users including older adults (38).

Technology also helps researchers and practitioners better understand person-environment interactions. For example, Geographic Information System (GIS) is used by professionals and researchers from various fields to study georeferenced and objectively assessed features of the physical environment. In addition, understanding the subjective perceptions, experiences, and preferences of people is also crucial. Geographical mapping of participant responses can help capture subjective perceptions or experiences of the environment that vary by individuals (39, 40). Such online questionnaires including citizen science platforms enable easy data collection and are increasingly used to fulfill requirements of participatory planning in addition to or in replacement of traditional face-to-face meetings. However, without providing support to those with limited digital skills, such methods may fail to reach a large part of the older population. When the provision of technical support is feasible, such methods have been successfully used to map older adults' use of the environment and related preferences (41).

Monitoring sensors enable collection of data on aspects of behavior, capacity, and the environment from the participant's perspective, relatively passively. For example, global positioning (GPS) units can be used to map an individual's activities in the environment, generating measures of the life/activity space, locations of and distances to activity destinations, and speed and time of movement. The movement speed and its variability can reflect transportation mode (e.g., vehicle, on foot) and functional capacity (e.g., walking speed) (42, 43). Data processing and analysis of GPS data are still challenging for researchers in health sciences without advanced geospatial training (39), but methodological advancements will continue to improve user accessibility/applications.

Opportunities for research and the potential to generate new insights in person-environment interactions will stem from unique combinations of people-based (e.g., health and function) and place-based (e.g., GPS or map-based questionnaires) data collected from participants linked with existing or newly collected environmental data (e.g., GIS or audits). This implies the importance of multidisciplinary research methods and collaboration of experts from different scientific fields, such as public health, urban planning, architecture, data science, and geoinformatics. Furthermore, place-based research may generate relevant information for planners and designers, thus highlighting the relevance of involving such professional actors in research to facilitate knowledge utilization. It is also important to note that data collection, linkage, and sharing may raise ethical concerns related to privacy and bias, which should be considered carefully in both research and practice.

Conclusion

Due to declining functions and limited energy reserves, older adults are more vulnerable to barriers in their physical and social environments than younger ones. Planning and design of activity-friendly communities for all ages should build on a deeper understanding of the complex dynamics underlying person-environment relationships considering the interlinked physical, social, and technological factors. This also suggests the need for interdisciplinary and multi-sectoral collaborations in research, intervention, and policy efforts (44). Technology will play an increasingly important role in knowledge generation as well as facilitating opportunities for active aging and aging-in-place. But it is important to ensure technological solutions are easy-to-use and accessible so that they do not present additional challenges to older adults with limited knowledge of or access to technology.

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.

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Societal- and community-level strategies to improve social connectedness among older adults

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social connectedness, social isolation, loneliness, community capacity, strategic initiatives, organizational collaboration

1. Introduction

Social disconnectedness is a complex and multi-faceted public health issue impacting individuals of all ages across the life-course. Social disconnectedness is characterized by the interrelated concepts of social isolation and loneliness stemming from limited contact or meaningful relationships with others, or related perceptions thereof. Older adults may be particularly at risk for social disconnectedness because they are more likely to live alone, experience loss or changes in their social networks (e.g., spouse, family, friends), and have chronic conditions and impairments (e.g., mobility, sensory, cognitive). In the United States, about 25% of older adults are considered to be socially isolated (1), which is an objective measure indicating the absence of a social network or the lack of social contact (2). Further, anywhere between 20% to 40% of older adults report moderate to severe loneliness (3–5), which can be described as the subjective, negative feeling from inadequate meaningful connections (6) or a lack of connection to other people despite the desire for more, or more satisfying, social relationships (7). People who feel they do not belong to majority social groups because of their gender identity, race, ethnicity, religion, language, or sexual orientation are at increased risk for social isolation, as are people living in rural areas, people with disabilities, immigrants, and individuals and families with financial struggles (8–11). The ramifications of social disconnectedness are vast and span poor physical (e.g., cardiovascular disease, stroke) (12–14) and mental (e.g., depression, anxiety) health outcomes, cognitive decline, risky health behaviors (e.g., substance use, physical inactivity, suicide), and all-cause mortality (2, 15–17).

Social connectedness is recognized as a core dimension of individual flourishing, health, wellbeing, and survival (18, 19). The longest longitudinal study of adults, the 75-year Harvard Study of Adult Development, found that an individual's satisfaction with their relationships was the greatest predictor of happiness and health (20, 21). Social connectedness has also been shown to be a key indicator of healthy aging later in life. Socially connected older adults are the core of an optimally functioning society (22). Living in socially connected communities can help older adults to thrive because it can increase neighborhood safety, strengthen resilience during societal crisis, encourage volunteerism, improve access to services and supports, and facilitate trust (23). Cognitive science demonstrates that friendships are critical for shared social pursuits of truth and that chronic forms of social isolation and loneliness contribute to distrust in social and political institutions (24).

While the consequences of social disconnectedness can be detrimental to the health, they may be symptoms of a fragmented and siloed society that obstructs and complicates efforts to build social connectedness for older adults (25). In this context, the purposes of this article are to: (a) describe societal-level challenges that foster social disconnectedness; and (b) provide opportunities and solutions to strengthen community capacity to foster social connectedness among older adults. This article brings together experts from public health, medicine, psychology, public policy, social sciences, and healthy community design to provide diverse perspectives through a unified lens to guide research, practice, and policy to drive community-level action.

2. Societal disconnectedness

Social connectedness is the degree to which an individual or population falls along the continuum of social connection, which includes (a) connections to others via the existence of relationships and their roles; (b) a sense of connection that results from actual or perceived support or inclusion; and c) the sense of connection to others that is based on positive relationship qualities (26, 27). Social connectedness is comprised of various interpersonal bonds (e.g., marriages, families, friendships)- bonds with strong (spouses, family, friends) and weak ties (infrequent, arms-length relationships), and various forms of participation in community life including memberships in civic, religious, social, and/or political organizations and networks that share common missions, interests, values, and beliefs (28). However, at times community systems and infrastructures can limit opportunities for interaction and participation, which can be detrimental to social connectedness.

In the context of public health, communities are "a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings" (29). Communities are comprised of interrelated systems that provide services and programs to improve and maintain older adults' health and wellness. To support mental and physical health, these networks can facilitate the initiation, maintenance, and strength of interpersonal bonds and participation in community life. Spanning the aging services network, public health system, and healthcare sector, each organization serving older adults has a unique mission, set of offerings, populations served, political ideologies, partnerships, regulating agencies, and funding sources. This uniqueness gives organizations autonomy in their operations and pursuits of societal impact. However, this may also lead to "silos" that result from financial and logistical barriers that limit coordinated, integrated service provision across sectors. Furthermore, systems have been designed to oppress and isolate people through policies such as redlining and highway development that disproportionately impact communities of color. This disenfranchisement and fragmentation within systems can breed distrust for government leaders and inefficiencies to reach, engage, serve, support, and treat older adults, which can ultimately disrupt the continuity of care and service delivery and reduce older adults' community participation and social connectedness.

Older adults residing within siloed and fragmented communities are at increased risk of being socially disconnected and not having their social needs met, especially those who experience poorer health, functional or sensory impairments, live alone, or experience additional marginalization (2, 8–11). Because older adults interact with many organizations across sectors for different reasons, these organizations share older adult clients and the responsibility to offer an integrated, coordinated set of "touch points" to address social isolation, loneliness, and general disconnectedness. Misaligned funding streams, competing demands and priorities, and general lack of uniformity across organizations and silos hinder community advancement and the ability to mitigate the health-related consequences of social disconnectedness. However, opportunities exist to bridge silos and narrow societal chasms through purposive collective action that advances research, practice, and policy.

3. Opportunities and solutions to strengthen societal and community capacity for social connectedness

A systems approach is needed to reduce societal silos, unify communities, and promote social connectedness among older adults. In this section, we offer nine opportunities and solutions to strengthen and unite communities to improve their cross-sector capacity to meet the social needs of older adults.

3.1. Raise awareness about social disconnectedness and advance it as a national priority

The prevalence of social isolation and loneliness among older adults warrants increased recognition as priority public health issues (27, 28). Dedicated awareness-raising efforts are needed to elevate recognition of the risks for, consequences of, and solutions to social disconnectedness among individuals, organizations, and policy makers. Tailored messaging and communication strategies are needed to garner support and buy-in from various stakeholders (30). Although social isolation and loneliness are often discussed and addressed through an individual-level lens, social disconnectedness is also a community-level issue, strongly rooted in social determinants of health framing as well as service and treatment inequities. More efforts are needed to complement and expand the visibility of existing initiatives that are raising awareness about social disconnectedness among older adults and other populations across the life-course [e.g., U.S. Administration for

Community Living (ACL)'s Commit to Connect (31), Foundation for Social Connection's Action Forum (32)].

3.2. Create a common nomenclature for use across sectors

Similar concepts are phrased and defined differently across disciplines, organizations, and community sectors. As such, it is important to identify commonly used terms and work within communities to establish a consistent terminology surrounding social disconnectedness. Creating a common nomenclature can reduce misunderstandings and facilitate efficiency during collaborations and information exchanges (33). For example, a uniform cross-sector taxonomy may be helpful to define risk factors and criteria, services and programs, and statistical methodologies and approaches.

3.3. Develop uniform screening across organizations and sectors

Because social disconnectedness can encompass many constructs [e.g., social isolation, loneliness, social networks, and social supports (2)], organizations commonly use different measures, scales, and screening tools to identify risk among older adults. Measures are commonly selected because of the mission of the organization, the clients they serve, and/or the requirements of their funding sources. However, the use of non-standardized measures (or non-standardized cut-points to indicate risk) can hinder a community's ability to document the prevalence of social disconnectedness or demonstrate collective impact when services and programs are offered through different organizations. It is beneficial to develop and routinely administer uniform and robust measures, which can be aligned with larger national and global initiatives for comparative purposes [e.g., inclusion of uniform social isolation and loneliness me asures collected by the Behavioral Risk Factor Surveillance System (BRFSS) (34) and National Health and Nutrition Examination Survey (NHANES) (35)].

3.4. Strengthen cross-sectoral referrals and community navigation

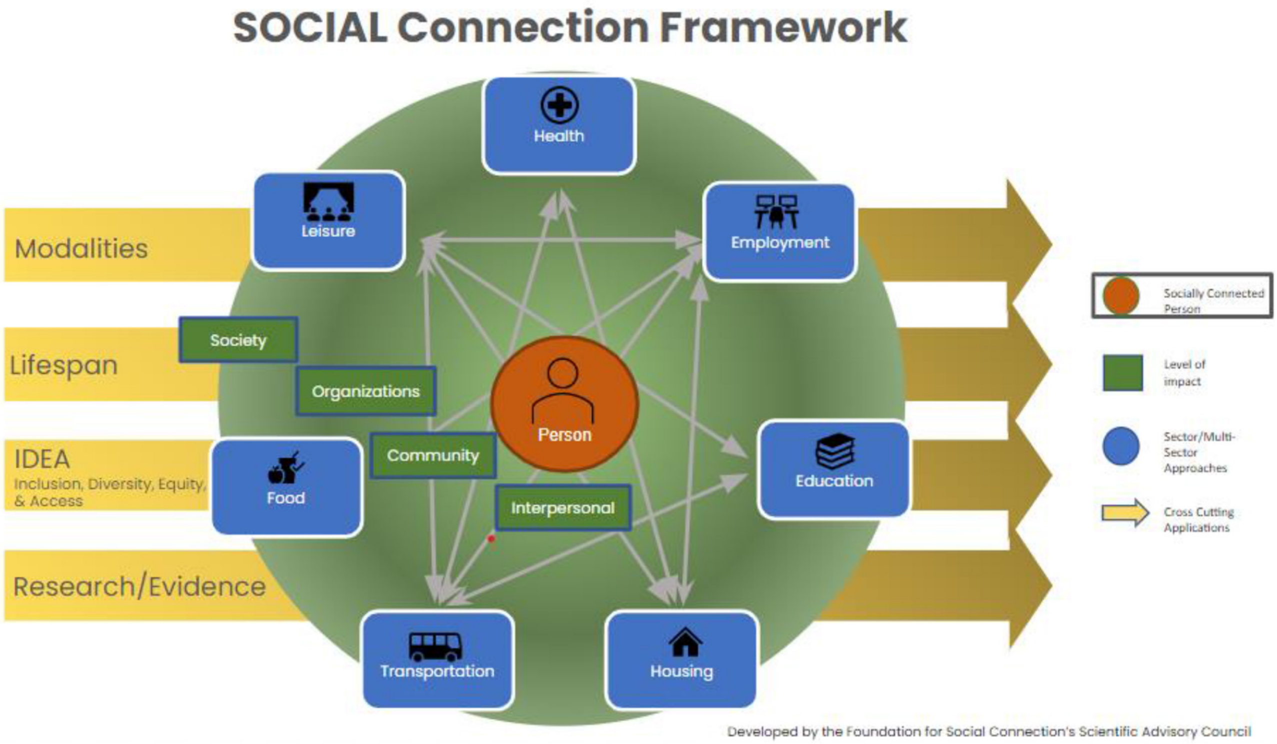
Each organization provides their own set of services and programs that address social disconnectedness. As such, the social needs of older adults may not be entirely addressed by any one organization. To ensure continuity of care for older adults across sectors, organizations should communicate about their respective services and resources (36) and establish seamless inter-agency referral criteria and processes. To enhance these referral systems, organizations should utilize trusted community navigators (e.g., community health workers, promotors, social workers, case managers) who understand specific cultural norms and needs, are familiar with community offerings, and can link older adults to appropriate services and programs. Social prescribing models may help older adults identify and access services and supports (37, 38). Further, technological advances may automate these referral and linkage processes and foster innovative community-clinical-industry partnerships (39, 40).

3.5. Establish and expand evidence about effective programs and services

Despite a growing recognition of the importance to address social disconnectedness, there are limited evidence-based programs and services shown to reduce social isolation and loneliness. Many of the interventions that have been tested are focused on individual interventions such as therapy, and less data exist about implementation and evaluation of community-wide or society wide interventions, social infrastructure, or policies. More also needs to be known about how inter-generational initiatives and various living arrangements affect loneliness and social isolation and influence interpersonal bonds and community participation (41). Additional efforts are needed to conduct controlled and pragmatic trials to assess the effectiveness of interventions to address social disconnectedness. It will be critical for such trials to integrate systems thinking approaches and consider the societal context within which trials are conducted to ensure aspects of equity, efficacy, replicability, and scalability can be addressed (42). To complement new interventions that specifically address social disconnectedness, existing interventions developed for other purposes should also be evaluated to determine their indirect benefits on social disconnectedness (43–45).

3.6. Improve community places and spaces to promote mobility and connectivity

Older adults with impairments (e.g., physical, sensory, cognitive), limited financial resources, or unreliable transportation may have additional difficulty accessing community resources and each other. As such, it is important to consider the built environment and physical infrastructure within a community to promote community-level mobility and connectivity. Inclusive public spaces are critical for all people to interact with one other, gain trust in community leaders, experience cultural activities, and gain a sense of belonging. Libraries, public parks, community gardens, community centers, and other types of social infrastructure are multifaceted and can improve social connectedness while providing many other benefits to individuals and the community (46). All community-level solutions should be developed with the input and participation of community members to ensure their needs, culture, and interests are included, especially those who are marginalized. Connectivity may be especially difficult in rural communities where resources are more geographically dispersed, which highlights the benefits of delivering services in easily accessible locations that are commonly frequented by older adults (e.g., faith-based organizations, senior centers, healthcare offices, commercial businesses) (47). For example, older residents have better connectivity to shared communal life when their built



Developed by the Foundation for Social Connection's Scientific Advisory Council

FIGURE 1
The Systems approach Of Cross-sector Integration and Action across the Lifespan (SOCIAL) Framework (27).

environment integrates civic, religious, and retail buildings with affordable housing (48).

3.7. Adopt unified, systems-level models

Collective planning across organizations and sectors is often contingent on utilizing a common framework. Such frameworks can help organizations better understand the roles and offerings of other organizations within a community, identify leverage points for collaboration, duplicative services, and service gaps which require additional resources or partnership. An example of an inclusive framework is the Systems approach Of Cross-sector Integration and Action across the Lifespan (SOCIAL) Framework (see Figure 1), which was developed by the Foundation for Social Connection's Scientific Advisory Council (SAC) "to facilitate and accelerate multi-stakeholder actions to reduce social isolation and loneliness, increase social connectedness, and identify opportunities for impact and gaps for additional research and solutions" (27).

3.8. Share and leverage funding and data

Funding for research and service provision has become increasingly scarce and competitive in recent years. While organizations rely on their own sources of funding to operate, leveraged funding through strategic partnerships can expand the scope and reach of services beyond the capabilities of any single organization. Public and private funders should consider ways to incentivize community wide collaboration, paying special attention to diversity, equity, and inclusion, to build social connectedness and community participation. Additionally, because each organization collects and generates its own data, efforts are recommended to share and leverage data across organizations and community sectors to alleviate data collection burdens, optimize understanding about older adult clients, and demonstrate collective impact. For example, Health Information Exchanges have been shown to facilitate community partnerships and identify cost savings for programs and services provided to residents (49–52). Another example is the Gravity Project, which defines social determinants of health information so it can be documented in and exchanged across disparate digital health and human service platforms to facilitate payment for social risk data collection and intervention activities (53).

3.9. Build inclusive, action-oriented strategic alliances

The formation of community-level coalitions, action alliances, and task forces can unify communities for a common mission. As such, these multi-organization, cross-sector entities can effectively incorporate each of the strategies mentioned above (e.g., raise awareness, create common nomenclature, adopt uniform screening, strengthen referrals, leverage funding). Examples of successful, model entities include the U.S. Coalition to End Social Isolation and Loneliness (CESIL) (54), Building Resilient and Inclusive Communities (BRIC) (55), U.K. Campaign to End Loneliness (56), Australian Ending Loneliness Together (57), and Global Initiative on Loneliness and Connection (GILC) (58).

4. Conclusion

Social isolation and loneliness among older adults are growing concerns in many communities across the world. These issues can have a significant impact on an older person's physical and mental health, leading to a decline in overall well-being. To meaningfully combat these problems, communities must recognize collaborative opportunities to address system injustices, transcend sectoral silos, synergize, and leverage efforts for the collective benefit of older adult connectedness.

Author contributions

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

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Conflict of interest

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

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Building the workforce to care for the aged: Can accreditation contribute?

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Building the workforce to care for the aged: Can accreditation contribute?

As the world's population ages, the workforce needed to care for older people is challenged in capacity and competence. Simply put, the world does not, at the present time, nor will it in the near future, have enough clinicians, support professionals, or caregivers to meet the complex and multi-faceted needs of the 1.6 billion people who will be aged 65 and above by 2050 (1). This paper explores the role that educational accreditation agencies could play in increasing the training of the workforce to care for the aged.

Matching need and supply through education

The rapid growth in the number of people aged 65 and older around the globe and in individual countries is well–documented (2). Among the older population, the number of people suffering from Alzheimer's disease and related dementias is also increasing (3). The numbers are relevant as they indicate the magnitude of the challenge to recruit and train the workforce required to care for older people, especially those with complex chronic medical conditions, orthopedic limitations, and mental decline, among other multi-faceted problems. Compared to the need, clinicians trained in geriatrics are in short supply (4).

In an ideal system, demand—represented by the increased number of older people, modified by some index to indicate complex healthcare needs—would be accommodated by supply—represented as jobs available and filled. Higher education would be directly related to employment, providing the training required of students to get the jobs available. Yet, in many countries in the world, the systems of higher education and employment are not directly related, accrediting agencies interject diversions, and demand for health and related services is distorted by payment systems, gatekeepers, and culture, among other issues. The argument proposed in this paper is that accreditation of university health professions educational programs is one intervention, overlooked as of now, that could bridge the disconnect between education and a much-needed workforce.

Training of clinical geriatricians

Despite the work of early pioneers on the special medical needs of older adults, recognition of geriatric medicine as a clinical specialty began in earnest only in the first half of the 20th century. The first faculty chair in geriatrics was established in 1965 in the United Kingdom (United Kingdom) (5). In the late 1970s, the United States (United States) made a major thrust to incorporate geriatrics into medical education and to establish advanced training programs (i.e., residencies and fellowships) in geriatric medicine (6). Other countries in Europe and throughout the world followed over the ensuing decades. The Malaysia Society for Geriatric Medicine, for example, prepared a comprehensive report in 2019 about the need for expanded efforts to meet the impending increase in the aged in Malaysia (7). Dentistry, too, began in the 1970s to examine the need for educating dental students to care for older adults. Brazil established the first geriatric dentistry specialty in 2010 (8).

Fast forward to the third decade of the 21st century, and the results of the wizened call for education of physicians, dentists, nurse practitioners, social workers, pharmacists, physical therapists, occupational therapists, and other health professionals who specialize in geriatrics are meager. The United Kingdom, the early leader in geriatric medicine education, reports having 1,747 consultant geriatricians, far less than the projected number needed if applying the approximate standard of 1 consultant per 800 older adults (9). The United States has about 7,100 geriatricians as of 2022 (10), but estimates 30,000 will be needed by 2025 (11). Australia, which projects that its population age 65 and older will increase from 16% of the total population in 2020 to 21–23% by 2066 (12), reported having 874 geriatricians in 2019, to serve a total nationwide older population of 4.2 million (13). Malaysia projects that its population age 60 and older will double from 7% of the country's total population in 2019 to 14% by 2040, or about 8.2 million people. Malaysia reports having only 40 geriatricians in 2019 (14). Dentistry has achieved a rate of education of about two-third of schools worldwide offering mandatory geriatric dentistry courses, but nonetheless questions if this is sufficient to meet the needs of the expanding number of older adults (15). These sample numbers and discipline-specific studies make it evident that the world will not produce enough geriatric specialists to meet the complex needs of the expanding aged population.

This shortage of specialists then leads us to assert that all health professionals should have at least a basic understanding of geriatrics. This would improve quality of care, spread the work, and use those who do have advanced training to care for older adults with the most complex conditions, as well as to lead the systemic changes that must be taken over the longer term to bring capacity closer to the need and demand for services.

Geriatrics education and accreditation

We would propose to incorporate geriatrics into the education of all health professions students, in all disciplines, at all stages of training. Except for countries where the governmental controls the content of education, the means to do so would be through requirements of the agencies that accredit health professions training programs. This does not take government action or new resources; it takes societal recognition of the importance of such training and commitment by the health professions and, in particular, the faculty and mentors who train today's students.

The majority of post-high school educational programs in developed countries, as well as many in developing countries (16), are driven by accreditation by an external body. Evidence suggests that, at the present time, accrediting agencies do not highlight care of the aged as an essential element of the education of a health professional. Although exceptions exist, this lack of attention to care of the aged seems to be pervasive across all disciplines in most countries. Educational accrediting agencies have power over university programs, their numbers are small enough to focus an effort for change, and the content of their work emanates from members of the field. These are conditions amenable for an advocacy campaign to succeed. Once well-known universities begin to change, others follow, whether forced by accreditation or a desire for quality or a business goal of being competitive.

One caveat is that accrediting requirements are often broad, allowing the university and faculty considerable leeway in constructing a curriculum and courses appropriate for their target audience of students and the local employment context. However, we have also seen that specific topics can be incorporated when deemed important by society. Recent examples include expectations for diversity, equity, and inclusion (DEI), social determinants of health (SDOH), and climate change. Why not geriatrics?

Current accreditation requirement content

If this were a research project, we would start with two questions: (1) Do the agencies that accredit health professions education include geriatrics among the topics required within a curriculum? And (2) If geriatrics is found to be required by accrediting agencies, does it make a difference in the expertise of health professionals in geriatrics and/or in the percentage of clinicians who choose to specialize in geriatrics? In preparation for a more extensive study, we conducted a pilot project to examine the criteria used by a variety of health professions accrediting agencies for different disciplines in various countries. We acknowledge that the examples do not represent any type of statistically valid sample. Nonetheless, the results are revealing. Select examples follow.

In the United States, the Council on Education for Public Health (CEPH) specifies the "foundational knowledge" required of all undergraduates and graduate students enrolled in degree programs granted by schools or programs of public health, as well as competencies required of master's and doctoral level students (17). CEPH specifies some content and competencies in great detail. Master's content areas include biological, genetic, behavioral, psychological, social, political, and economic factors the affect health, and for undergraduate knowledge, "opportunities for promoting and protecting health across the life course." Neither undergraduate nor graduate public health students are required to know specifically about aging. In contrast, a graduate-level competency specifically focuses on "racism." With regard to other demographics, and specifically aging, however, CEPH is silent. With about 25,000 new enrollees per year in public health graduate programs alone, many more students could become aware of the conditions faced by the aging population.

Nursing basic education may incorporate training about the care of older adults, but it lacks a clear directive to focus on older adults as a priority. The Accreditation Commission for Education in Nursing, which accredits nursing education programs in the United States, clearly avoids any specification of content (18). Nonetheless, its Standards do include topics deemed important, such as "health literacy" and "use of technology." The National Council Licensure Examination (NCLEX) is taken by all nursing program graduates in the United States. Accredited schools typically prepare their students to take and pass the exam. The exam has eight content categories organized by clinical topic. Although questions about older adults might be scattered throughout the exam, no specific instructions alert the nursing student or their professors that students should know about geriatrics.

The Japan University Accreditation Association accredits six types of university education programs and publishes standards, including Dental Education Standards (19). Although Japan has one of the highest proportions of aged populations in the world, no mention is made of the need to incorporate knowledge of geriatrics into the dental curriculum.

The Australian Physiotherapy Council accredits Australian higher education entry-level programs in physical therapy (20). Program of Study Requirement 3.3 and Foundational Ability "C" include knowledge of clients "across the life span," but do not call out geriatrics per se.

In Ghana, the National Accreditation Board accredits university programs in the health professions disciplines of medicine, nursing, pharmacy, dentistry. For nursing, all curricula and exams are regulated by the Nurses and Midwifery Council of Ghana (21). After 3 years of basic education, students are eligible to pursue specialties, which include community nursing, ophthalmologic nursing, pre-operative nursing, ENT nursing, public health nursing, critical care nursing, nurse anesthesiology, and community oral health—but not geriatrics or chronic illness care.

Accreditation requirement vagueness

When geriatrics is included in curricula, the content and extent of training can be highly varied. Physicians in training in the United States are expected to meet the Minimum Geriatric Competencies for Medical Students (22), but how these are taught is left to each School of Medicine to weave into its curriculum. One well-recognized program requires students to spend 1 month doing an in-person clinical rotation in Pediatrics, a separate in-person rotation on OB/GYN delivery, and 1 week doing a virtual course on Geriatrics. The content is there, assessed by an on-line exam, but the proportion is inconsistent with the demographics of most patient panel populations.

A recent study comparing geriatric dentistry curricula across six continents found that geriatric dentistry was a mandatory course in more than two-thirds of the 83 responding dental schools representing 24 countries (23). Similarly, about two-thirds had mandatory clinical rotations in geriatric dentistry. Other schools had elective courses in geriatric dentistry. Differences were not explained by type of school, location, or method of teaching. That means that one-third of dental schools *do not* have geriatrics in didactic or clinical training and those that do exhibit wide variation.

Discussion

Research shows that students are more likely to choose a career path if they have had exposure to it through their life or education experiences. Incorporating basic education about geriatrics into the curricula of all health professions disciplines could be one means to increase access by older adults to appropriate health care and related services. Entities that accredit colleges, universities, and other educational programs could drive changes to health professions curricula to incorporate geriatrics. This should not be a token inclusion, but a comprehensive, in-depth, practice as well as theoretical, addition to academic and applied training.

Moreover, agreement among and across accrediting agencies could produce a consistency in baseline education across disciplines. A shared baseline knowledge and a realistic expectation of how other disciplines have been trained would lead to more effective interdisciplinary teams to deal with the multi-faceted clinical needs of older adults.

How does one control accrediting agencies? The majority of accrediting bodies, whether focused on educational curricula or competencies required of an individual for licensing or certification, are comprised of health professionals working in a given field. Expert panels are brought together to delineate subject matter and competencies. Recommendations are vetted among more professionals from the same discipline and at times across disciplines. Content is driven by the latest evidence from the field, not by commercial or personal interests. Conceptually, then, it should be possible to educate those involved in writing the accreditation "standards" of the importance of addressing the aging of the world's population and the rationale for including baseline content. Striving for compatibility or harmony across disciplines would lend even greater perspective and perhaps a wide array of educational self-study tools that span disciplines.

Critics might argue that this approach is naïve and unrealistic. We would counter that when society embraces wide-spread acceptance of a problem, a solution is possible. Despite more than 50 years of trying to build a workforce of expert geriatricians, the world and most individual countries have failed to do so. Those involved with the care of older adults must exert leadership and launch a serious initiative for awareness and change.

Conclusion and next steps

Myriad factors inhibit providing an adequate supply of well-trained health professionals to meet the growing, multi-faceted demand of an aging population. The above argument is offered as one suggestion to an extremely complex, recalcitrant problem. Next steps from an academic perspective would be a comprehensive geriatric workforce analysis: an enumeration of available specialists by discipline, by country or region; a comparison to the current and future demand of the aging population; a detailed analysis of educational programs, competency models, accrediting entities, and criteria for accreditation of university education programs, as well as certification and licensure for individuals. These tasks alone cannot solve the shortage in the workforce to care for the aged that relate to poor system infrastructure, low salaries, geographic maldistribution, student preferences, or cultural differences. Nonetheless, they can provide some insights into one path that might lead to progress over the long-term. Following a Stages of Change model, making care of the aged a well-known, well-publicized international problem is the first step toward future improvement, and starting with increasing the awareness of health professionals through accreditation requirements may be a good beginning.

Author contributions

This manuscript was conceived of and written by CE.

Conflict of interest

The author declares 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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Developing a dissemination and implementation research agenda for aging and public health: The what, when, how, and why?

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translational sciences, knowledge translation (KT), dissemination & implementation research, reach, effectiveness, adoption, implementation and maintenance (RE-AIM)

Introduction

To improve the uptake of evidence-based interventions in the fields of aging and public health there have been calls to apply the methods, models, and measures of dissemination and implementation science (DIS) (1, 2). DIS may be defined as the scientific study of the strategies and mechanisms by which research evidence is adopted, applied, and sustained in community or clinical settings to improve outcomes for a specified population (3, 4). Early work in DIS focused on expanding the reporting of outcomes. This translated into including, but moving beyond efficacy or effectiveness, when testing interventions to improve health outcomes and balancing internal and external validity in the development and testing of new interventions (5). In one early framework, these expanded outcomes were initially summarized by our research team using reach, effectiveness, adoption, implementation, maintenance (RE-AIM) dimensions (5, 6). Within RE-AIM, multi-leveled dissemination outcomes were operationalized at the level of the population intended to benefit (i.e., reach) as well as the staff, settings, and systems (i.e., adoption) intended to deliver an intervention (7). At each level of dissemination, researchers were encouraged to address representativeness, engage the populations and systems that could most benefit, and advance health equity (8, 9). Similarly, implementation outcomes were operationalized within RE-AIM at the staff, setting, and system levels to include the degree to which an intervention was delivered as intended (i.e., implementation), the costs associated with implementation, adaptations made, and the potential for sustainability (i.e., organizational level maintenance).

In addition to expanding outcomes, understanding context is a key aspect of DIS (10, 11). Contextual factors related to DIS outcomes provide constructs that can act as moderators, mediators, or mechanisms of success (4, 12). Indeed, the field has seen a proliferation of theories, models, and frameworks to provide systematic approaches to understand the relationships between contextual factors and outcomes (13–15). For example, the Practical, Robust, Implementation, and Sustainability Model (PRISM) provides constructs multi-level constructs of potential beneficiaries (e.g., economic status; compatibility of intervention with lifestyle) and potential implementers (e.g., expertise; complexity of intervention implementation); implementation and sustainability infrastructure (e.g., structured communication channels); and external environmental factors (e.g., community resources to support or inhibit dissemination and/or implementation) (16, 17). Each of these contextual constructs, when tied to a specific RE-AIM outcome, can be used to map strategies to improve outcomes that can be tailored to address contextual moderators or designed to leverage contextual mediators or mechanisms that lead to success (16, 18).

Over the past 2–3 years there have been several articles articulating how DIS can be applied to aging and health issues (1, 9, 19, 20). Of particular relevance is a paper by Carpenter et al. (19) that discusses how addressing DIS outcomes, moderators, mediators, and mechanisms using the Standards for Reporting Implementation Studies (StaRI) can be applied to advance DIS and aging research. The STaRI guidelines summarize key DIS issues under the various sections of a manuscript for reporting on DIS studies. For example, in the introduction, identification of the DIS theory or framework used is recommended while in the methods section clear operational definitions of the implementation context, outcomes, and economic evaluation are encouraged. The results and discussions sections are recommended to include information on fidelity to protocol, intervention adaptions, and generalizability to other typical clinical or community settings.

Developing a DIS research agenda for aging and public health

Several researchers have developed guidance and recommendations about advancing DIS. To develop successful projects and outcomes, Kilbourne et al. (21) recommended the use of a conceptual model, collaborative methods (e.g., development of a shared agenda, implementation strategies, adaptation recommendations with key system partners), and focusing on building system capacity and a business case for sustained implementation. Other recommendations for advancing DIS include using mixed methods to capture important contextual and systems factors that may not be quantifiable (22, 23) and pragmatic approaches to maintain a focus on generalizability and usability of implementation strategies and outcomes relevant to typical clinical and community settings (24). In addition, to these recommendations, we propose the following areas for DIS in aging and public health.

Focus on the how, what, when and why of dissemination and implementation

Early DIS often focused only on documenting the achievement of implementation (e.g., RE-AIM) outcomes. *Active for Life*, a multi-site project promoting physical activity in older adults is a good example. The primary focus was on determining if evidence-based physical activity programs could be delivered in typical community settings and demonstrate effectiveness (25, 26). Process evaluation also demonstrated that, possibly due to the collaborative nature of the multi-site trial, there was high implementation fidelity across communities and that communities adapted the interventions to improve fit with delivery settings (27). Studies like *Active for Life* were critical in addressing external validity and effectiveness, and set the stage for current DIS in aging to focus on understanding not only if dissemination and implementation outcomes can be achieved, but also *on understanding how those outcomes can be achieved by monitoring what strategy was used, and when, in the implementation process as well as analyzing why the outcome occurred by examining prespecified mechanism(s) or mediator(s).*

Recently, Implementation Research Logic Models have been introduced as an example of how to better support DIS researchers and clinical or community partners to conceptualize and test the how, what, and why of dissemination and implementation outcomes (28). This approach encourages the use of theory to characterize contextual factors that can be used to (a) determine barriers and facilitators related to achieving DIS outcomes, (b) develop context-specific implementation strategies, and (c) identify potential mechanisms and mediators of change that (d) explain if and how changes in DIS outcomes occur as a result of an implementation strategy. We developed Figure 1 as a simplified example of how aging researchers could apply DIS using information from an excellent article on the Strategies to Reduce Injuries and Develop Confidence in Elders (STRIDE) pragmatic trial of an intervention for Falls Care Managers to reduce fall-related injuries in older adults (29).

To orient readers to the Figure each row reflects a path model that begins with barriers, strategies to overcome barriers, mechanisms, and outcomes relative to theory-based contextual factors—in this case using PRISM. The STRIDE investigative team reported on qualitative data they used to identify contextual factors that could inhibit intervention implementation and on strategies used across sites to address those factors. For ease of presentation, we only focused on barriers in the figure and linked barriers to reported strategies and then identified potential mechanisms based on PRISM contextual factors. Finally, the Figure identifies the primary DIS outcome that is most likely to change in response to the implementation strategy through the proposed PRISM mechanisms. Of note, implementation research logic models are prone to reductionism and our example uses a reductionist approach for simplicity. However, we also demonstrate that the barrier-strategy-mechanism-outcome link can be very complex with a single strategy, in part, addressing several implementation barriers (e.g., identify low/no cost community resources to support implementation) or conversely several DIS strategies may be needed to address a single barrier. Further, strategies often do not work through a single mechanism and a single mechanism is typically not responsible for a single DIS outcome. As such, we recommend the use of practical tools, such as logic models, to map out proposed relationships, develop hypotheses, and guide trials, but also to avoid oversimplification of the context-strategy-mechanism-outcome relationships.

Acknowledge and address context and adaptations as dynamic factors

Related to the recommendation to avoid oversimplification and reductionism, relevant and active areas of DIS for aging and public health researchers include addressing multi-level contextual factors and adaptation. While public health has historically focused on multiple socio-ecological levels and multiple determinants of health (30), DIS has focused more specifically on key components of context (e.g., implementation infrastructure related to available pragmatic implementation feedback loops) and how the evidence-based programs align with key aspects of context (31). One of the central tenets of DIS is that context is not static, but changes over time, sometimes very rapidly as was seen during the initial (and ongoing) COVID-19 pandemic (11). Understanding, tracking and

Contextual Factors	Implementation Strategies	Mechanisms	Outcomes
Participant (Older Adult) Characteristics & Perceptions **Barriers:** out of pocket costs, transportation difficulty	Participant (Older Adult) Characteristics & Perceptions **Strategies:** identify low/no cost community resources to support implementation; introduce home care-based delivery	Participant (Older Adult) Characteristics & Perceptions **Mechanisms:** ease of participation; compatibility with older adult lifestyle and resources	Participant (Older Adult) Characteristics & Perceptions **Outcomes:** Reach (primary), Effectiveness, Maintenance of Health Benefits
Organization (Primary Care/Falls Care Managers) Characteristics & Perceptions **Barriers:** lengthy protocol, fall care management not part of usual care	Organization (Primary Care/Falls Care Managers) Characteristics & Perceptions **Strategies:** Allow protocol adaptations based on expertise; ID low/no cost community resources	Organization (Primary Care/Falls Care Managers) Characteristics & Perceptions **Mechanisms:** compatibility with provider expertise; reduced implementation complexity	Organization (Primary Care/Falls Care Managers) Characteristics & Perceptions **Outcomes:** Adoption (primary), Implementation, Maintenance of Implementation
Implementation & Sustainability Infrastructure **Barriers:** limited clinical space, variable buy in.	Implementation & Sustainability Infrastructure **Strategies:** ID low/no cost community resources; integrate with other existing screenings; ongoing feedback on implementation	Implementation & Sustainability Infrastructure **Mechanisms:** improved implementation climate; accountability for change	Implementation & Sustainability Infrastructure **Outcomes:** Implementation (primary), Maintenance of Implementation, Adoption
External Environment **Barriers:** less compatible with larger fee-for service reimbursement environment, copayment costs high	External Environment **Strategies:** Identify low/no cost community resources to support implementation; integrate with other existing screenings	External Environment **Mechanisms:** compatible with external drivers, improved community relations	External Environment **Outcomes:** Adoption (primary), Implementation, Maintenance of Implementation

FIGURE 1
An example application of dissemination and implementation science in aging research: STRIDE, a national study to prevent fall related injuries.

adapting to contextual changes undergirds DIS and illustrates how it is different than other types of health outcomes research (8, 11, 32).

Adaptations and the balance between evidence-based program implementation fidelity and context specific changes (e.g., tailoring) is critical for implementation success and sustainability (33, 34). DIS posits that fidelity should be to core functions or principles rather to a rigid protocol, and that adaptions to clinical context and conditions may also be necessary (35, 36). One DIS approach that is broadly applicable and often more intuitive than other approaches for community and clinical partners is that of *form* and *function*: that there should be fidelity to the key goals or *functions* of an evidence-based program [e.g., reinforce quality implementation (36)]. But that the specific *forms* of activities to address these functions should be tailored to specific contextual factors. Public health has always been sensitive to the need to adapt to cultural and local community factors using approaches such as community-based participatory research (37), but DIS extends this focus on adaptations across the lifespan of a program and to address adaptations to the EBP, the strategies used to implement the program, and the context itself (16). DIS authors have also focused on the need for adaptations to address issues of health equity (8) and for programs to be sustainable (11).

Aging and public health research needs to be much more rapid than it has traditionally been to be relevant to decision makers and community groups, to respond to rapidly changing context, and to contribute to learning health systems. One active area of DIS focuses on how to speed the application and relevance of dissemination and implementation research (38, 39). It is acknowledged that research must be not only Rapid, but also Relevant to community and clinical partners, Rigorous, attend to Resources Required, and Replicable [the 5 Rs (40)]. With context continually changing, it is usually the case that adaptions need to be iterative and there is active D&I research applying D&I frameworks in ways that are rapid and iterative (41, 42).

Begin with the end in mind

It may seem obvious but DIS is best conceptualized by initiating action with an eye toward what outcomes are intended. In the early DIS work there was focused on the concept of designing for dissemination (43). It included thinking about the characteristics of interventions that may be most likely to be adopted in typical service settings and to plan for dissemination from the outset of a project. This concept of designing for dissemination has been expanded and we recommend aging and public health researchers interested in DIS take the approach of designing for dissemination, equity, and sustainability (44). This work often includes careful selection of delivery system partners to ensure there is a broad representation in, for example, senior-serving settings, to ensure that those providing services for populations experiencing health disparities and inequities contribute to intervention and implementation strategy design decisions (45). Theory is, again, important in the process of designing for dissemination, equity, and sustainability. For example, considering the ideal or preferred intervention characteristics using PRISM contextual factors focused on participant and organizational perspectives can result in interventions that are attractive to underserved audiences and aligned with the assets available in the organizations that serve that audience (46).

The need for de-implementation

While DIS focused initially on the getting evidence-based interventions into practice, there is also need for the de-implementation of low value interventions that that may be either ineffective or harmful (47). De-implementation and de-intensification represent a growing area of DIS in aging and public health in which new theories and methods may be needed to reduce the use or overuse of ineffective or harmful interventions (19). To help providers decide when and how to "de-adopt" treatments in patients with complex needs. Indeed, the removal of care that may be perceived as potentially beneficial by older patients could be especially challenging for de-implementation (19). User-centered approaches that include patients and providers in the identification of pathways toward de-implementation or de-intensification may be promising approaches, particularly for older adults (48).

Conclusion

Focusing on the what, when, how, and why of dissemination and implementation will advance the speed of translation, as well as the broader public health impact, of evidence-based interventions in aging and public health. We note that this brief article is necessarily cursory and several other DIS recommendation and guidance documents exist for scientists and practitioners that also include many more useful examples. In addition, we used RE-AIM and PRISM as our examples of outcomes and contextual DIS frameworks, though there are a myriad of other frameworks from which to choose. As with our recommendations for matching context-strategy-mechanisms-outcomes, we encourage those in aging and public health research to investigate what is available and pick what seems to be the best fit for your research question and context. There are great resources such as www.dissemination-implementation.org and Brownson et al. (49) that can help facilitate framework selection. Additionally, we invite researchers and practitioners to engage with the National RE-AIM Workgroup and visit (www.re-aim.org) to learn more about public health approaches to improving population health across the life course.

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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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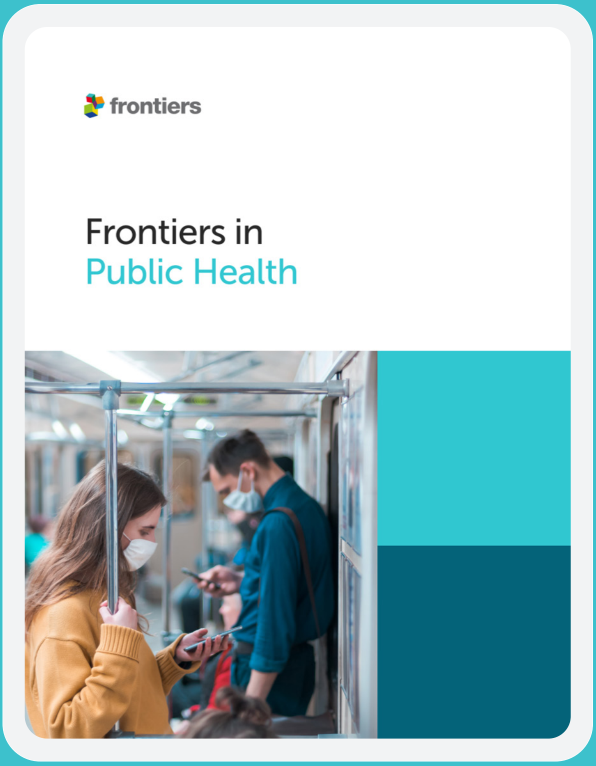

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