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Future of AgeTech: Transdisciplinary Considerations for Equity, Intersectionality, Sustainability, and Social Justice

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ABSTRACT
As societies experience the rapid demographic shift towards increased older adult populations, more health and social wellbeing efforts are being invested in the shape of AgeTech – at the individual level, to better support older adults to live well longer, and at the societal level, to offset financial and human-resource costs to care. For these reasons, AgeTech products, services and supports are ever more pervasive within health and social care systems worldwide. Yet, there has been limited action-oriented discussions and plans to develop ethical design, digital equity and policy pathways for sustainable AgeTech through assessing the intended impact and unintended consequences of a digitization on the everyday realities of older people. Critical dialogue on how AgeTech solutions can be cultivated to drive practical, equitable, and inclusive multilevel solutions to support healthy and active aging is needed. In this paper, the key social justice disparities that may unintentionally increase the vulnerability of older adults are discussed, and promising intersectional pathways regarding the ways in which we can enhance digital equity and sustainability for future AgeTech development are provided.

CCS CONCEPTS
• Human-centered computing~Accessibility~Accessibility design and evaluation methods

Additional Keywords and Phrases: Aging and technology, Digital equity, Intersectionality, Social justice, Sustainability and impact

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1 Introducing the digital challenge
Aging, health and technology is a growing field that requires innovative approaches to ensure people across societies can live and age well. Innovation requires us to better understand the needs, aspirations and everyday lives of older people and to develop practical solutions in a socially just and equitable way that translates into products and services which are useful and accessible in everyday contexts [1]. Over recent decades, there has been a dramatic increase in research and technology development focusing on aging and technology as more people, globally, will require assistance with aspects of daily living and disease management. While the intent is to
develop and implement innovations including information and communication technologies; artificial intelligence; mobile technologies; technology-related services; methodologies for user-centred design; and policies for implementation and practice. Such innovation rarely reaches the people who need it the most, such as older adults living with multiple health challenges, who have a low-income, have limited social support, and reside in rural or remote places and/or with limited exposure to using technology [2].

As technology advanced, concerns regarding digital inequality were raised [3]. Known as the digital divide, this concept was initially conceived in reaction to a 1995 report, Falling through the Net, which discussed the unequal access to emerging information and communication technologies (ICTs) [3]. Subsequently, a plethora of research had emerged highlighting how exclusion from the benefits of technology can result in widening social, health, and economic disparities supporting the notion that digital exclusion should be viewed as a digital determinant of health and wellbeing [4]. A social justice framework for bridging the digital divide, developed by Fang and colleagues [4] through a realist review, made visible how digital service challenges facing older people were best understood according to issues of human-rights, intersectionality, and social justice.

Amid the pandemic, when access to technology has been vital for accessing health and social care, digital exclusion was viewed as an issue of life and death [5]. Fang and colleagues describe, in particular, the interplay of complex social factors that shape access and use of technologies developed to support age-related challenges — described here as AgeTech. As an extension of this work, this discussion unpacks the key social justice disparities that may unintentionally increase the vulnerability of older adults and provides some pathways to enhance digital equity and sustainability for future AgeTech development.

2 Intersectional digital inequalities

There are several social factors that create inaccessibility and non-use of AgeTech and five are found to be associated with digital inequality: (i) exposure to technology; (ii) income; (iii) age and generation; (iv) physical and cognitive comorbidities; and (v) social support status discussed in the following sections [6] [7] [8] [9].

2.1 Exposure to technology

One of the most salient creators of digital inequality is exposure to technology either through the education system or employment [10]. Linked to formal education and employment is level of education. Level of education has been demonstrated in several studies and in population statistics as one of the key primary predictive social facts for digital access and uptake in middle to older aged adults [6] [7] [8]. The more education acquired, the more likely individuals will have had exposure to ICTs, such as computers and the Internet through certain types of employment, rendering them less fearful and more confident in AgeTech use, in general, in old age [11] [12] [13] [14].

2.2 Income

A key determinant of vulnerability in later life is income, especially as it pertains to encroaching technology driven spaces and places. Digital divide research has found that income was identified early on as a primary contributor to digital inequality that, in turn, influences social and health disparities and continues to be a key determinant of not only Internet access, but also online activity level [11]. Older adults are more likely to use ICTs and other AgeTech if they have higher incomes and the financial means to purchase a computer, pay for an Internet connection, and/or technologies that are relevant to them [4] [15].

2.3 Age and generation

Aging is a process associated with various individual, social and structural vulnerabilities, such as difficulties navigating health and social care systems, frailty, chronic health conditions, mental health and mobility challenges, ageism, and social exclusion [16]; while the concept of age in itself is also a key social determinant of
health [17]. For people older than 70 years of age, the relationship between age and technology use such as Internet usage was found to be not linear but rather exponential. Approximately 4.9% of older people in the age bracket of 85+ years are using the Internet regularly, and within every five years younger thereafter this approximation doubles (9.4% to 19.7% to 40.0%) [18].

It is important to note that chronological age does not appear to be a causal factor in technology access and use but, instead, it is the generational difference in technology exposure that provides the explanatory power [3]. While age might be a useful tool for targeting policies and programs, it is important to consider the implications and nuances of this factor. Older adults are not all the same meaning their past technology experiences, physical, social and cognitive needs, financial situation, and their adaptability will differ across geographical and cultural contexts [19]. The problem with a one-dimensional group-focus on an ability to work with technology and experiences of older adults is that it risks furthering ageist views, stigmatizing and essentializing certain negative stereotypes oppressions to aging populations. Hence, more nuanced ways of understanding age in association with AgeTech usage are being explored, including considerations that cohort or generation rather than chronological age have more of a role. It appears that cohort differences may have more powerful explanatory potential as it captures familiarity and life stage when technologies were introduced [20] [21].

2.4 Physical and cognitive co-morbidities

Older adults and in particular older people with long-term physical, such as arthritis, and/or cognitive health conditions, such as dementia, or those with intellectual or development mental disability were found to use and be able to access technology substantially less than individuals without comorbidities. Research has shown that they are much less likely to access ICTs such as computers, tablets, smart phones to get online, which means that they are more likely to be socially isolated with a limited ability to receive health and social care supports and benefits afforded by digital powers [22].

To date, research that examines how disability status impacts access and use of AgeTech, in particular ICTs, is varied. However, being older and also having a learning disability or cognitive issues was associated with lower use as was having vision, hearing, or hand-related disability (e.g., arthritis) [18] [22]. Accordingly, approximately half of Internet non-users over age 85 years indicated that vision or hearing limitations were the primary reason for non-use [18].

2.5 Social contact and support status

The COVID-19 pandemic has made visible the digital vulnerability of people with limited in-person and online social contact and support living in rural and remote parts of the world [23]. In rural and remote communities, ICT accesses a particular issue given the increased importance of high-speed Internet connection for accessing services, supports, and goods as well as for the economic development of disadvantaged rural communities [24].

According to Mack and colleagues, the digital divide remains a priority topic in global policy and research especially because it intersects considerably with the rural and urban divide [25]. For older generations, the use of social networks when living in rural areas promotes social inclusion and minimizes loneliness and social isolation, especially in older women. Incidentally, the requirement of social isolation as a means to combat the viral spread of the pandemic has prevented much needed social interaction in rural and remote places. Without social contact, older adults who are widowed or are living alone are specifically at higher risk of emotional and psychological problems including elevated risk of developing depression and dementia that can ultimately lead to reduced quality of life and life expectancy [26] [27].

Social support facilitates AgeTech engagement and access; and has been found to narrow the digital divide gap. For example, being an engaged, socially active older adult was found to be positively associated with ICT use and access [28] [29]. Research has found that older adults that are new users of technology report that children, grandchildren, and peers’ encouragement and support compelled them to use technology [4]. However, it is important to not conflate notions of social support and the socialization of technology use. Societal norms shaped
by the socialization of technology use can both support or disrupt ICT use and access. Older adults who embrace ageist stereotypes portraying them as incapable of technology use are less likely to attempt, consider or see relevance in engaging with AgeTech. Yet, socialization of technology use which serves to normalize and empower people to use technology by involving them in the design and delivery of technology will likely encourage critical mass of technology adoption and use.

Although each of these social factors have been discussed in research on its own, less widely understood and discussed is the combined effect of these social determinants that shape the everyday experiences of digital access.

3 An intersectional place perspective for digitally inclusive environments

In general, AgeTech development has been part of a technological movement towards creating more digitally-inclusive environments and are largely viewed as an egalitarian, socially transformative initiative for the greater public good [30]. However, according to some, the purpose, intent as well as the AgeTech design and development process has been hampered by vested interests through the prioritization of elite capitalists [31] [32]. In fact, there continues to be an inequitable distribution of power during technological advancement [5]. Globally, the gradual expansion of digital spaces and places has been driven by a neoliberal agenda that has often focused on profit as a marker success, rather than the social transformation of communities.

According to research, technology development has tended to benefit the wealthy over the poor [4]. This is demonstrated by the progression of the digital divide, which has notably further marginalized some groups such as older adults and/or adults with low-incomes, who may live alone with limited social supports in rural or remote places [23] [5].

An Intersectional Place Perspective (IPP) model (see Figure 1) was first developed to help address such complexities shaped by combined social factors that influence a person’s ability to age well in technology-driven environments [33]. IPP has been used as a critical analytical perspective to inform aging in place research, policy, and practice during a time whereby access to vital resources are determined by technology knowledge and know how. This theoretical framework combines theories of intersectional feminism and place to derive important questions that should be asked in relation to social justice and digital equity, and provides an analytical tool for enabling critical understandings of data and discourse.

![Figure 1](https://example.com) ©Mei Lan Fang. Illustrates an Intersectional Place Perspective informed by critical social theories: Intersectional Feminism and Place Theories
In previous research [34], the IPP helped to reveal important stories of place vulnerabilities and opportunities of older low-income adults centering how their intersectional identities and positionalities had shaped their past and present experiences of aging, poverty, migration, loneliness, privilege, well-being, and historical trauma. Applying IPP enabled self-reflexivity to occur and helped researchers, developers, and planners during an affordable housing redevelopment project to challenge prioritization of certain knowledges (i.e., by academics, industry professionals) over others (i.e., older adults, not-for-profit service providers).

The critical, social justice roots of IPP implore AgeTech researchers and developers to be reflexive about the impact of the innovation design and development process; working towards socially-informed, equitable, and collaborative mechanisms to create welfare-oriented technology initiatives considerate of generational and aging related needs of older adults to age well in place.

4 Transdisciplinary working in AgeTech

World leaders in AgeTech research and innovation such as AGE-WELL NCE have seen the benefits of ‘transdisciplinary working,’ which is the notion of transcending perceived boundaries between disciplines and integrating diverse perspectives from scientific and non-scientific sources to create new ideas and socially informed solutions to complex real-world problems [35]. Through its attention to participatory modes of research, development, and knowledge mobilization, older people and other stakeholders contribute in inclusive ways ensuring that technology is developed with purpose, together with and for older people.

There is increasing demand for academics and other professionals in the field of aging and technology to engage in cross-disciplinary, community-oriented, and collaborative forms of research that actively involve the integration of knowledge across diverse academic/scientific, industry, government, and citizen boundaries [36]. One approach for this way of working is through transdisciplinary research (TDR) [37]. TDR shifts away from single disciplinary modes of working towards team-based knowledge production to co-create solutions for application in real-world settings. Often, researchers and developers believe that they are undertaking transdisciplinary work, however, this may come across in ways that are tokenistic such as involving one token older individual in an advisory group. To help to ensure TDR is conducted correctly and with impact, there are ways to undertake multiple trans-sector analysis as part of AgeTech development [37]. Summarized in the following points are key criteria for TDR impact assessment [38] [37]:

- Variability of goals and activities. Requires a more dynamic assessment approach compared to traditional research evaluation frameworks. Suggestion for indicators includes variability in trans-sectoral goals; number of multiple methods applied; number of product development outputs; and degree of collaboration.
- Variability of impact assessment indicators. Requires a set of outcome indicators that assess contributions to enhance quality of life in real world settings. These should consider contributions by multiple disciplines and sectors. Suggestions for indicators include number of new policies; number of new protocols; number of patents; number of products introduced into society; and number of copyrights, trademarks, and
- Leveraging integration. Requires assessment for effectiveness in different fields and/or disciplines. Suggestions for indicators include ideas and methods uptake in different disciplines (can be assessed by citation counts in different disciplinary journals); number of presentations in conferences of diverse disciplinary fields; uptake of products in various sectors (product per sector) for example health, social work, long-term care, and others.
- Problem solving in collaborative working. Varied disciplinary standards and ways of working can often create tension between different working groups. Suggestion for assessment includes a log of conflict resolution (type of conflict; how conflict was resolved).
- Management, leadership, and coaching. It is important to assess the effectiveness of leadership and teamwork. Suggestions for indicators include number and frequency of team meetings; number and frequency of team social activities; number and frequency of one-on-one coaching; and number and frequency of paid training activities.
• Iteration and feedback in a comprehensive and transparent system. TDR requires iterative ideas generation and a feedback process that is transparent and easy to understand. Suggestion for indicators include: log of iterations and collaborators involved in the feedback process. Projects can track the number of iterations performed and number of collaborators involved in the review process prior to finalizing outputs.

• Effectiveness and impact. TDR is inherently time and resource intensive. Visibility of impacts may be delayed, tend to be unforeseeable and difficult to capture by a priori methods. Suggest integration of longitudinal methods of assessment.

Tracking, monitoring and evaluating to help to ensure effective transdisciplinary working is taking place in a project does not have to be an onerous process – as demonstrated by the various ways that it can be assessed. The crucial point here is to have practical mechanisms for evaluating sustainability and impact from AgeTech research and product development.

5 Ensuring real world impact for sustainability

It is important to recognize first and foremost the value of conducting sound AgeTech research; and to realize that the purpose of research excellence is to innovate through trial and error, create evidence to support hypotheses and generate products to help our society make intelligent decisions for the greater good of improving the human condition. Intelligent decision-making has been defined as “decisions and choices that achieve particular outcomes with the least amount of resources and at the same time takes issues of equity and fairness into account” [39]. It is also important to note that such outcomes must ultimately enhance or benefit our society so as to enrich quality of life. Research impacts in AgeTech are the demonstrable and sustainable social and economic contributions that excellent research has made to an evolving digital society. It is understood as having several elements. For instance, academic impact involves advances in science across disciplines and includes important developments in methods, theory, and applications in the real-world [40]. At the same time, economic and social impact should occur alongside academic outputs, emerging at multiple levels, benefiting individuals, communities, organizations, and across nations [40].

Research impact in AgeTech can materialize in several different ways, “through creating and sharing new knowledge and innovation; inventing ground-breaking new products, companies and jobs; developing new and improving existing public services and policy; enhancing quality of life and health; and many more” [40]. To ensure that this occurs, it is important that contingencies for evaluating impact are built into research plans at the outset.

Ensuring real world impact from research matters because spending public funding, tax dollar contributions people and communities mean that we are accountable to generating tangible societal benefits. To do this effectively, we need to make certain that AgeTech research is efficient and of high quality, maximizing benefits to those we aim to serve in the shortest time possible. This entails identifying key oversights that often occur at the outset of technology research and development including lack of direction; limited knowledge or understanding; under-budgeting or poor prioritization; and difficulties developing a set of activities and/or measures that are transparent, easy to implement, verifiable and inexpensive to implement or collect [39]. Many of these challenges can be addressed through a robust performance management framework that can be applied across research projects and disciplines. However, developing an innovation-driven performance management framework that is both rigorous and fit-for-purpose necessitates a review and assessment of existing models, integrating strengths while noting limitations; guiding principles fundamentally based on innovation philosophies; and this is followed by a well-defined plan for refinement, validation, and execution.

6 Concluding remarks

Progression of digital products and services amid COVID-19 has provided a window of opportunity for developing genuine age-friendly design of digital environments. However, this will require advancing the AgeTech movement
through a focus on digital equity and social justice, by mapping out the intersectional intended and unintended positive and negative impacts of AgeTech, ensuring a process of working with and for older adults and communities, and developing an impact and sustainability evaluation plan at the outset.

When creating AgeTech products, services as well as policy, avoidance of a "us and them" attitude is crucial and can be achieved by highlighting and challenging normative power relationships that tend to prioritize professional voices over those expressed by older adults and local community.

Prioritizing notions of digital inclusivity, diversity, and equality is essential to effective age-friendly, development suggesting that research and product design need to progress hand-in-hand, and that intersectional theories such as the IPP would be a useful resource to frame how people's characteristics and social positionalities in addition to age will be considered in AgeTech conceptualization. Identifying a specific role and method for technology in age-friendly design to build and share ideas, to interconnect across communities, cities and countries globally to promote inclusivity, diversity, and equality is thus paramount.

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