Editorial

Enhancing Aging Research in Public Health

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Over the past decades, population aging has fundamentally reshaped the global disease spectrum and health services. Although increased human life expectancy represents a landmark achievement in public health, it has also extended the period of "living with morbidity"[1], posing challenges to traditional healthcare systems focused on disease treatment. Consequently, a paradigm shift from "disease management" to "health maintenance" has become a critical priority.

Aging is widely recognized as a fundamental upstream risk factor for many chronic diseases[2]. Aging is far more than a mere increase in chronological age; it is a complex biological process involving intricate regulatory networks across multiple layers[3] (e.g., molecular, physiological, and functional dimensions), as well as interactions across organ systems[4]. This complexity and multidimensionality require both breadth and depth in aging research. To date, clinical research has largely focused on classic geriatric phenotypes, such as frailty, sarcopenia, cognitive impairment, and intrinsic capacity[5-10]. These phenotypes have also gained extensive attention in public health and serve as critical dimensions in comprehensive geriatric assessment within population-based cohort studies. Meanwhile, advances in omics technologies have made aging increasingly "quantifiable". By identifying aging-associated biomarkers (e.g., DNA methylation sites and proteins), researchers have developed various "aging clocks"[11], enabling the quantification of aging rates. Evidently, aging research is increasingly entering the purview of public health; however, despite these advances, integrating aging research into public health frameworks remains underexplored.

Numerous modifiable determinants, including environmental exposures, socioeconomic status, and lifestyle factors, can influence chronic disease risk by altering aging rates[12-14]. Consequently, a research paradigm centered on the pathway of "environmental exposure→accelerated aging→ chronic disease", with aging research as a central hub, offers a promising direction for overcoming the bottlenecks of chronic disease control by shifting the "intervention window" to an earlier stage. Nevertheless, the interplay between aging and chronic diseases is far more complex than this simplified model suggests. Diseases themselves can modify aging trajectories; for instance, individuals with cardiovascular disease exhibit distinct patterns of accelerated aging compared with disease-free counterparts. Meanwhile, aging interacts dynamically with environmental exposures and multiple disease outcomes in ways that remain incompletely understood.

Enhancing aging research in public health would deepen our understanding of the pathophysiological mechanisms of diseases and improve health promotion. Here, we call for embedding aging research within the three-tiered disease prevention and control. In primary prevention, efforts should focus on strengthening health maintenance (e.g., by controlling aging-related risk factors) across the life course—from early-life and even prenatal stages to health promotion in late-life. In secondary prevention, aging assessments can serve as core tools for population-level health risk stratification, enabling early personalized lifestyle interventions for high-risk groups. Given that many aging measurements have been well-established and widely validated, we advocate incorporating some of these functional indicators, aging clocks, and other assessment tools into population-based cohort studies, community health management, primary healthcare, and other settings. For instance, communities include a substantial population of subclinical individuals who experience physical discomfort and functional decline without overt clinical disease, and thus are rarely screened out by

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conventional public health surveillance systems. In this vulnerable population, aging assessments may identify high-risk groups undergoing accelerated aging, enabling timely health management before illness becomes manifest. This approach aligns with the public health principle "prevention before disease onset". In tertiary prevention, among patients with chronic conditions such as cancer and cardiovascular diseases, evaluating aging status may help optimize treatment strategies and improve prognoses within disease management. By doing so, aging research can be extended from "basic science" into the realm of "clinical and public health", enhancing its translational impact.

Meanwhile, multiple challenges remain to be resolved. First, aging research typically relies on high-quality, large-scale longitudinal data. The rapid evolution of research technologies (e.g., the continuous updating of novel aging clocks) imposes higher demands on the timeliness and adaptability of research data. To meet these challenges, we advocate establishing cross-institutional, standardized longitudinal databases, coupled with unified data collection protocols and dynamic updating mechanisms. Additionally, leveraging cloud computing and secure data-sharing platforms can enhance data storage, processing efficiency, and accessibility, ensuring that datasets keep pace with technological advances and support robust, reproducible aging research. Second, aging research requires holistic and integrated insights. Traditional aging research often operates within isolated disciplinary boundaries, hindering the translation of basic research findings into effective public health prevention and interventions. To address this fragmentation challenge, we advocate cultivating a new generation of interdisciplinary professionals equipped with foundational knowledge in public health, life sciences, clinical medicine, public administration, nursing, and other disciplines. This also means embracing emerging technologies and tools such as artificial intelligence when advancing aging and public health research and practice.

In summary, although the public health application of aging research remains in its early stages and continues to face substantial challenges, the rapid advances in big data, omics technologies, and artificial intelligence have ushered in a golden era of deep integration between aging research and public health practice. In moving forward, prioritizing multidisciplinary collaboration to overcome existing barriers, advancing technological innovation to optimize aging assessment and intervention tools, and strengthening multifaceted support to embed aging research into public health frameworks will collectively position aging research as a central driver of population health improvement across the life course.

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