

Public policy response, aging in place, and big data platforms: Creating an effective collaborative system to cope with aging of the population

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Summary

The unprecedented rapid aging of the population is poised to become the next global public health challenge, as is apparent by the fact that 23.1% of the total global burden of disease is attributable to disorders in people aged 60 years and older. Aging of the population is the biggest driver of substantial increases in the prevalence of chronic conditions, and the prevalence of multi-morbidity is much higher in older age groups. This places a large burden on countries' health and long-term care systems. Many behavioral changes and public policy responses to aging of the population have been implemented to cope with these challenges. A system of "aging in place" has been implemented in some high-income countries in order to better provide coordinated and cost-effective health services for the elderly. This approach reduces institutional care while supporting home- or community-based care and other services. Advances in information and communications technology (ICT), assistive devices, medical diagnostics, and interventions offer many ways of more efficiently providing long-term care as part of aging in place. The use of big data on a web services platform in an effective collaborative system should promote systematic data gathering to integrate clinical and public health information systems to provide support across the continuum of care. However, the use of big data in collaborative system is a double-edged sword, as it also brings challenges for information sharing, standardized data gathering, and the security of personal information, that warrant full attention.

Keywords: Older people, public health, institutional care, home-based care, community-based care, information platform

1. Introduction

Advances in medicine and socioeconomic development have substantially improved life expectancy worldwide. According to estimates from the World Health Organization (WHO), the worldwide average life expectancy was 72.7 years for females (ranging from 59.0 years in Africa to 82.0 years in high-income countries), and 68.1 years for males in 2012 (ranging from 56.3 years

in Africa to 75.8 years in high-income countries) (Table 1) (1,2). Typically, women in Japan have the longest life expectancy in the world at 87 years (2).

There is no doubt that the increased longevity is one of the most remarkable success stories in human history. Coupled with decreased fertility rates, however, it is now ushering in unprecedented rapid aging of the population. Demographic projections suggest that the world's population aged 60 years and older is set to rise from 841 million in 2013 to more than 2 billion by 2050 and exceed the number of children by 2047 (3,4). By 2050, 21.1% of the world population will be 60 years or older, and 80% of this demographic group will live in low-income and middle-income countries, compared to about two-thirds at present (4,5).

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Table 1. Life expectancy (LE) and healthy life expectancy (HALE) by country-income group worldwide*

Country income group	Males				Females			
	LE at birth (years)		HALE at birth (years)		LE at birth (years)		HALE at birth (years)	
	2000	2010	2000	2010	2000	2010	2000	2010
High income countries	72.4	75.8	64.7	67.5	79.6	82.0	70.0	72.0
Low- and middle-income countries								
African Region	49.0	56.3	42.4	48.8	51.4	59.0	43.8	50.4
Region of the Americas	70.8	73.5	62.7	64.9	77.0	79.3	67.2	69.1
Eastern Mediterranean Region	63.6	66.1	54.8	57.4	66.4	69.7	56.1	59.2
European Region	68.2	72.4	60.7	64.2	76.7	79.6	67.1	69.6
South East Asian Region	61.6	65.7	53.5	57.4	64.3	69.4	55.0	59.7
Western Pacific Region	70.0	73.9	63.0	66.6	74.8	78.1	66.7	69.8
Worldwide	63.9	68.1	56.4	60.1	68.5	72.7	59.7	63.4

*Data are from WHO methods for life expectancy and healthy life expectancy 2014 (1), and WHO World Health Statistics 2014 (2).

2. Burden of disease as a result of aging of the population

Aging of the population is poised to become the next global public health challenge (6). An analysis of data from the Global Burden of Disease study shows that 23.1% of the total global burden of disease is attributable to disorders in people aged 60 years and older; 49.2% of the burden is found in high-income countries while 19.9% is found in low-income and middle-income countries (7).

The major causes of death and disability in older age (≥ 60 years) are non-communicable diseases, regardless of a country's income level (8,9). In addition, infectious disease morbidity and mortality in many low-income and middle-income countries increasingly affect older people because of the aging population and changes in the epidemiology of some diseases such as HIV/AIDS or tuberculosis (10,11). Globally, the leading contributors to disease burden in older people are cardiovascular diseases (30.3% of the total burden in people aged 60 years and older), malignant neoplasms (15.1%), chronic respiratory diseases (9.5%), musculoskeletal diseases (7.5%), and mental and neurological disorders (6.6%) (Figure 1) (7,12).

Aging of the population is the biggest driver of substantial increases in the prevalence of chronic conditions, such as dementia, stroke, chronic obstructive pulmonary disease, and diabetes, that are strongly associated with age (6). Furthermore, the prevalence of multi-morbidity is much higher in older age groups, with 65% of people aged 65-84 years and 82% of people aged at least 85 years affected (13). Therefore, the age-appropriate care for chronic diseases and the complexity of integrating care for complex multi-morbidity are sharp exemplars of the challenges faced by health-care systems across the world in the 21st century (14).

3. Public health response to aging of the population

The Madrid International Plan of Action on Ageing

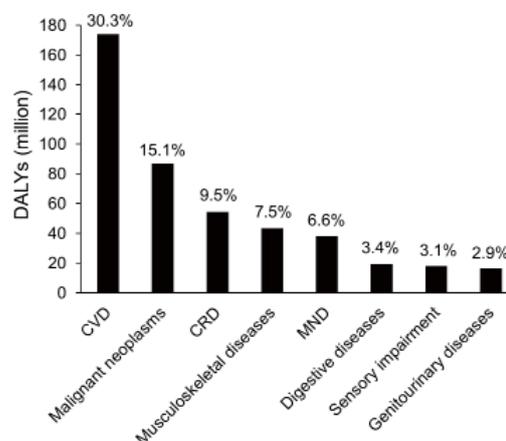


Figure 1. Leading contributors to the burden of non-communicable diseases in people aged 60 years and older in 2010 (IHME GBD) (7,12). Disability-adjusted life years (DALYs) data based on global burden of disease (GBD) estimates from the Institute of Health Metrics and Evaluation (IHME). CVD, cardiovascular diseases; CRD, chronic respiratory diseases; MND, mental and neurological disorders.

called for the elimination of social and economic inequalities in access to health care and the development of healthcare and long-term care to meet the needs of older people (15). Furthermore, the Post-2015 Development Agenda indicates that the goal of ensuring healthy lives and promoting wellbeing for everyone at all ages cannot be achieved without attention to the health of older people (6).

Over the past few decades, improvements in the effectiveness and coverage of health care and reduced exposure to environmental, behavioral, and biological risk factors have played a role in mitigating the disease burden posed by aging of the population. Data show that many behavioral changes and public policy responses to aging of the population have the potential to mitigate the disease burden (16,17). Smoking cessation, a reduction in excessive alcohol consumption, adherence to healthier diets, engagement

in more physical activity, and taking advantage of adult vaccines such as those for influenza, pneumococcal disease, human papillomavirus, and shingles, are behavioral responses that should promote improved health in older people (18-21). Regardless of how effectively non-communicable chronic diseases and even some communicable diseases are prevented or delayed, however, many older people will inevitably be affected. Therefore, continuous monitoring and interventions are urgently needed for older people.

Continuous monitoring and interventions for older people poses challenges for countries' economies and health systems. These approaches will place a large burden on health and long-term care systems since increased health-care spending at older ages is largely driven by much higher outlays in the final years of life (22). Health systems need to find cost-effective strategies to expand health care and to respond to the needs of older people. Health care that is effective, safe, efficient, and responsive and that avoids imposing an unbearable financial burden on older people will be central to achievement of the goal of universal health coverage. Additionally, older people are increasingly living alone or as part of a couple, rather than in the larger, multigenerational households of the past as a result of increased spatial mobility and changes in family structure. For example, in some European countries nearly 50% of women aged 65 years or older live alone (23). In addition, many older people want to continue to live in their home and their community where they have been living for a long time even if they are ill (24). These changes are stimulating increasing debate on the role of the government and family in providing long-term care to many older people who need it. Faced with this challenge, some high-income countries have been working to reduce institutional care while supporting home- or community-based care and other services that enable older people to remain in their own homes or a home-like environment. This approach is known as "aging in place".

4. Aging in place (home- or community-based care) to provide coordinated and informed geriatric services

An extension of basic packages of cost-effective interventions to match the needs of older people with appropriate technologies, effective treatment of chronic diseases is needed to reduce disability. To optimize their functioning, health systems could be redesigned to better provide coordinated and informed geriatric services that enable older people to age in place (*e.g.*, at home or in the community) to the extent possible (25). Ideally, these services would be seamlessly linked with social and long-term care to provide a continuum of care that extends from home or community to institutional care (24,26). Core services would include prevention and early detection of disease, acute and

chronic care, rehabilitation, provision of assistive devices, and palliative care (26).

Many long-term care programs for aging in place have been implemented in high-income countries such as Australia, Canada, and the United States (27-29). Over the past decade, Japan's government-initiated, mandatory, public, long-term care insurance (LTCI) system has ushered in increased use of aging in place at a reduced cost to households (30). Unlike systems elsewhere that rely on cash allowances for long-term care of older people, the Japanese LTCI system only provides services and recipients can choose their services and providers, on the grounds that family caregivers benefit most from direct help with their tasks and that quality of care is best assured by relying on trained, licensed, and supervised caregivers. Many services are covered by the LTCI system in Japan (31): *i*) services in the home, including a home helper (housekeeping and personal care), a visiting nurse, bathing, remodelling to accommodate an elderly family member, and assistive devices; *ii*) services outside the home, including day care, day care with rehabilitation, and short-stay respite care; and *iii*) institutional services, including nursing homes, homes with more medical services, and chronic-care hospitals. Additionally, the costs of care in private nursing homes and group homes for individuals with dementia are covered.

Launched in 2000, the Japanese LTCI system has been in place for more than a decade and now serves nearly 5 million people (32). The number of beneficiaries in institutions increased by 83%, but more notable has been the 203% increase in those receiving home and community-based services in the program's first 10 years (32). Largely on the basis of the Japanese approach, the South Korean Government started long-term care programs that essentially opted for a services-only strategy, and personnel in Taiwan hope to implement a similar system (33,34).

5. Information and communications technology to integrate clinical and public health information systems to provide support across the continuum of care

The goal of aging in place is to improve health outcomes in older people and to improve the personalization of services while reducing inequalities in both health outcomes and responsiveness. Data show that aging in place can be simple and cost-effective while simultaneously offering substantial benefits to the individual (24,35). This approach can also meet the increasing need for improved quality of life for older people by emphasizing home- or community-based care for patients in the interim stage after the completion of acute-stage treatment or for end-of-life care (36). However, the needs of older people frequently blur the lines between disease prevention and health promotion as defined by public health practices in previous eras

(37,38). In addition, older people, family caregivers, clinicians, system designers, public health practitioners, and policymakers have different technology and information needs (24). Accordingly, the pressing issue is to use modern technology to deliver healthcare services. Specifically, this means developing systematic data gathering to integrate clinical and public health information systems to provide support across the continuum of care.

Advances in information and communications technology (ICT), assistive devices, medical diagnostics, and interventions offer many ways of more efficiently providing long-term care as part of aging in place. For example, the advent of wearable devices that can continuously monitor physical activity may rapidly transform our understanding of functional trajectories and their determinants. Other innovations use low-cost laptop computers with sensors to read vital signs and perform electrocardiograms, allowing images to be sent to trained physicians at other locations, and create electronic health records; this could avoid the need for travel and dealing with long and uncertain waiting times (26,39).

Furthermore, integrated platforms have been created with the aid of ICT in recent years to provide comprehensive health services to older people. For example, the Australian e-Health Research Centre and Queensland Health have developed an innovative Care Assessment Platform, an ICT-enabled home-care cardiac rehabilitation program (40). With the aid of mobile phones and the Internet, the Care Assessment Platform can provide all the elements of traditional cardiac rehabilitation for patients recovering from a myocardial infarction, including education, mentoring, goal-setting, personal feedback, and counseling over a 6-week period. Based on the latest advances in research on big data, a program named the Intelligent Aging-in-place Home care Web Services Platform is being implemented in Taiwan (41). This program has a cloud computing setting to offer personalized healthcare services everywhere to facilitate the most desirable and cost-efficient provision of care as part of aging in place.

6. Use of big data as a double-edged sword: Information sharing, standardized data gathering, and the security of personal information

The use of big data on a web services platform to facilitate aging in place should promote systematic data gathering to integrate clinical and public health information systems to provide support across the continuum of care. However, aging in place is a comprehensive system including public health, medical treatment, nursing care, and welfare work. Given that the availability of medical care resources varies considerably in different regions, an effective collaborative system should be established, and this

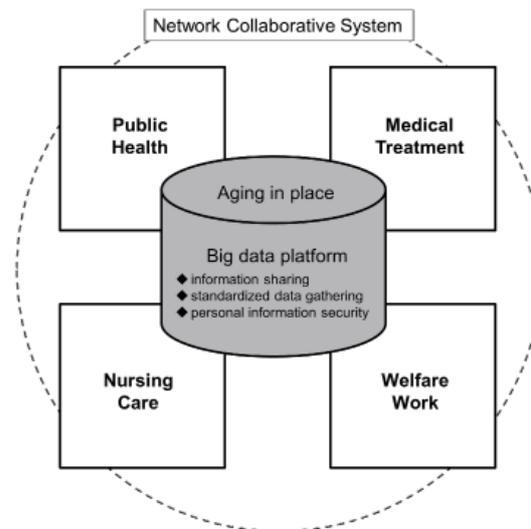


Figure 2. Exploration on an effective information network with standardized data gathering and management to integrate health services for the elderly in public health, medical treatment, nursing care, and welfare work in Japan.

system should be tailored to the region in order to capitalize on local characteristics. A point worth noting, however, is that such a collaborative system is a double-edged sword. The use of big data in a collaborative system also brings challenges in terms of information sharing, standardized data gathering, and the security of personal information.

In light of this challenge, Japan drafted "The Guideline to Promote the Appropriate Use of Information Systems in Care for the Elderly in Conjunction with At-home Care" in 2014 (42). The Guideline is intended to foster an effective information network with standardized data gathering and management to integrate health services for the elderly in public health, medical care, nursing care, and welfare work (Figure 2). This information network seeks to collect 237 pieces of information in the 5 categories of "patient attributes", "residence and family", "medical treatment", "nursing care and lifestyle," and "diagnosis, treatment and care". The aforementioned guideline has standardized data entry, changes to data, data use, and personnel responsible for the system. Such a collaborative system based on big data with standardized data gathering and management should promote clinical and public health information systems to provide support for the elderly across the continuum of care.

7. Conclusion

Age-appropriate care for chronic diseases in the elderly and the complexity of integrating care for complex multi-morbidity are sharp exemplars of the challenges faced by health-care systems across the world in the 21st century. Data show that aging in place could be a

simple and cost-effective approach that simultaneously offers substantial benefits to the individual. An example of that approach, the Japanese LTCI system was designed to help family caregivers by having the government handle some aspects of care. The LTCI system has ushered in the increased use of aging in place at a reduced cost to households.

Effective collaborative systems based on big data are now being examined and put into practice through the use of modern technology to deliver healthcare services and the development of systematic data gathering to integrate clinical and public health information systems to provide support across the continuum of care. However, the use of big data in a collaborative system is a double-edged sword. To cope with challenges in terms of information sharing, standardized data gathering, and the security of personal information, Japan drafted the guideline for creation of an effective information network with standardized data gathering and management. The resulting network should integrate health services for the elderly in hospitals, home-based care, community-based care, and institutional care.

References

- WHO. WHO methods for life expectancy and healthy life expectancy. Geneva: World Health Organization. www.who.int/healthinfo/statistics/LT_method.pdf (accessed November 15, 2014).
- WHO. World health statistics 2014. Geneva: World Health Organization. http://www.who.int/gho/publications/world_health_statistics/2014/en/ (accessed November 17, 2014).
- United Nations Department of Economic and Social Affairs Population Division. World Population Ageing 2013. <http://www.un.org/en/development/desa/population/publications/ageing/WorldPopulationAgeingReport2013.shtml> (accessed November 16, 2014).
- Chatterji S, Byles J, Cutler D, Seeman T, Verdes E. Health, functioning, and disability in older adults - present status and future implications. *Lancet*. 2015; 385:563-575.
- United Nations Department of Economic and Social Affairs, Population Division, population Estimates and Projections Section. World Population Prospects: The 2012 Revision. <http://esa.un.org/unpd/wpp/index.htm> (accessed November 19, 2014).
- Suzman R, Beard JR, Boerma T, Chatterji S. Health in an ageing world - what do we know? *Lancet*. 2015; 385:484-486.
- WHO. The global burden of disease. 2004 update. Geneva: World Health Organization. http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_full.pdf (accessed December 2, 2014).
- Wilmoth JR. Demography of longevity: Past, present, and future trends. *Exp Gerontol*. 2000; 35:1111-1129.
- Fries JF. Aging, natural death, and the compression of morbidity. 1980. *Bull World Health Organ*. 2002; 80:245-250.
- Adjuik M, Smith T, Clark S, et al. Cause-specific mortality rates in sub-Saharan Africa and Bangladesh. *Bull World Health Organ*. 2006; 84:181-188.
- Aboderin IA, Beard JR. Older people's health in sub-Saharan Africa. *Lancet*. 2015; 385:e9-e11.
- Prince MJ, Wu F, Guo Y, Gutierrez Robledo LM, O'Donnell M, Sullivan R, Yusuf S. The burden of disease in older people and implications for health policy and practice. *Lancet*. 2015; 385:549-562.
- Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: A cross-sectional study. *Lancet*. 2012; 380:37-43.
- Banerjee S. Multimorbidity - older adults need health care that can count past one. *Lancet*. 2015; 385:587-589.
- United Nations. Report of the Second World Assembly on Ageing. http://www.un.org/en/events/pastevents/ageing_assembly2.shtml (accessed December 4, 2014).
- Christensen K, Doblhammer G, Rau R, Vaupel JW. Ageing populations: The challenges ahead. *Lancet*. 2009; 374:1196-1208.
- Doyle Y, McKee M, Rechel B, Grundy E. Meeting the challenge of population ageing. *BMJ*. 2009; 339:b3926.
- Do R, Xie C, Zhang X, et al. The effect of chromosome 9p21 variants on cardiovascular disease may be modified by dietary intake: Evidence from a case/control and a prospective study. *PLoS Med*. 2011; 8:e1001106.
- Lorig KR, Holman H. Self-management education: history, definition, outcomes, and mechanisms. *Ann Behav Med*. 2003; 26:1-7.
- Chakravarty EF, Hubert HB, Krishnan E, Bruce BB, Lingala VB, Fries JF. Lifestyle risk factors predict disability and death in healthy aging adults. *Am J Med*. 2012; 125:190-197.
- He FJ, Pombo-Rodrigues S, MacGregor GA. Salt reduction in England from 2003 to 2011: Its relationship to blood pressure, stroke and ischaemic heart disease mortality. *BMJ Open*. 2014; 4:e004549.
- Mcgrail K, Green B, Barer M, Evans R, Hertzman C, Normand C. Age, costs of acute and long-term care and proximity to death: Evidence for 1987-88 and 1994-95 in British Columbia. *Age Ageing*. 2000; 29:249-253.
- Tomassini C, Glaser K, Wolf DA, Broese van Groenou MI, Grundy E. Living arrangements among older people: An overview of trends in Europe and the USA. *Popul Trends*. 2004; 115:24-34.
- Reeder B, Meyer E, Lazar A, Chaudhuri S, Thompson HJ, Demiris G. Framing the evidence for health smart homes and home-based consumer health technologies as a public health intervention for independent aging: A systematic review. *Int J Med Inform*. 2013; 82:565-579.
- Yarmo-Roberts D, Freak-Poli RL, Cooper B, Noonan T, Stolewinder J, Reid CM. The heart of the matter: Health status of aged care clients receiving home- and community-based care. *J Aging Res*. 2010; 2010:275303.
- Beard JR, Bloom DE. Towards a comprehensive public health response to population ageing. *Lancet*. 2015; 385:658-661.
- Horner B, Boldy DP. The benefit and burden of "ageing-in-place" in an aged care community. *Aust Health Rev*. 2008; 32:356-365.
- Ouellet MC, Sirois MJ, Beaulieu-Bonneau S, Morin J, Perry J, Daoust R, Wilding L, Provencher V, Camden S, Allain-Boulé N, Émond M. Is cognitive function a concern in independent elderly adults discharged home from the emergency department in Canada after a minor injury? *J Am Geriatr Soc*. 2014; 62:2130-2135.

29. Satariano WA, Scharlach AE, Lindeman D. Aging, place, and technology: Toward improving access and wellness in older populations. *J Aging Health*. 2014; 26:1373-1389.
30. Campbell JC, Ikegami N. Long-term care insurance comes to Japan. *Health Aff (Millwood)* 2000; 19:26-39.
31. Tamiya N, Noguchi H, Nishi A, Reich MR, Ikegami N, Hashimoto H, Shibuya K, Kawachi I, Campbell JC. Population ageing and wellbeing: Lessons from Japan's long-term care insurance policy. *Lancet*. 2011; 378:1183-1192.
32. Ministry of Health, Labour and Welfare (MHLW). Report on various current states around LTCI (Kaigo hoken seido wo torimaku genjo). <http://www.mhlw.go.jp/stf/shingi/2r985200000123iu-att/2r985200000123se.pdf> (accessed December 10, 2014). (in Japanese)
33. Kim H, Kwon S, Yoon NH, Hyun KR. Utilization of long-term care services under the public long-term care insurance program in Korea: Implications of a subsidy policy. *Health Policy*. 2013; 111:166-174.
34. Hsieh HF, Chen KM, Lin MH, Wang YC, Huang HT. Social welfare utilization and needs of older adults in Taiwan: Survey research. *Nurs Outlook*. 2014; 62:459-468.
35. S Arai Y, Iinuma T, Takayama M, et al. The Tokyo Oldest Old survey on Total Health (TOOTH): A longitudinal cohort study of multidimensional components of health and well-being. *BMC Geriatr*. 2010; 10:35.
36. Kubo M. Long-term care insurance and market for aged care in Japan: Focusing on the status of care service providers by locality and organisational nature based on survey results. *Australas J Ageing*. 2014; 33:153-157.
37. Stults BM. Preventive health care for the elderly. *West J Med*. 1984; 141:832-845.
38. Breslow L. Health measurement in the third era of health. *Am J Public Health*. 2006; 96:17-19.
39. Bloom DE, Chatterji S, Kowal P, Lloyd-Sherlock P, McKee M, Rechel B, Rosenberg L, Smith JP. Macroeconomic implications of population ageing and selected policy responses. *Lancet*. 2015; 385:649-657.
40. Varnfield M, Karunanithi MK, Särelä A, Garcia E, Fairfull A, Oldenburg BF, Walters DL. Uptake of a technology-assisted home-care cardiac rehabilitation program. *Med J Aust*. 2011; 194:S15-S19.
41. Su CJ, Chiang CY. IAServ: An intelligent home care web services platform in a cloud for aging-in-place. *Int J Environ Res Public Health*. 2013; 10:6106-6130.
42. The Institute of Gerontology of The University of Tokyo. The Guideline to Promote the Appropriate Use of Information Systems in Care for the Elderly in Conjunction with At-home Care. <http://www.iog.u-tokyo.ac.jp/wp-content/uploads/2014/05/5435d2ad3a28ce3767b71b2bfb764856.pdf> (accessed December 12, 2014).

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