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Strengthening and Sustaining Health-Related Outcomes Through Digital Health Interventions

Raj Kumar Goel[1] and Shweta Vishnoi[2*]

[1]Department of Computer Science & Engineering, Noida Institute of Engineering & Technology, Affiliated to Dr. A.P.J Abdul Kalam Technical University, Lucknow, U.P, India
[2]Department of Physics, Noida Institute of Engineering & Technology, Greater Noida, Affiliated to Dr. A.P.J Abdul Kalam Technical University, Lucknow, U.P, India

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Abstract

Healthcare ICT includes a range of interventions including telemedicine, electronic health records (EHR), data analytics, artificial intelligence, sensor technology, and wearables devices. In achieving the Sustainable Development Goals (SDGs), the time has come to accelerate the development of affordable and sustainable health systems that respect people's needs and values. Because, as a component of a health program, it can augment capacity and improve the overall effectiveness of a health development program. Digitalization and technological advances, including sensors, are transforming connected healthcare into inclusive healthcare, enabling remote monitoring and support for chronically ill patients both inside and outside healthcare facilities. Therefore, wearable biosensors are becoming increasingly effective in the prevention, early diagnosis, control, and treatment of diseases. It has also been observed that due to the COVID-19 epidemic, the world has undergone a radical shift in healthcare with a new shift towards Remote Patient Monitoring (RPM). Assistive ICT also ensures safety, social communication, and greater independence for elderly and vulnerable people with chronic diseases. Bearing in this mind, ICT-assisted healthcare paradigm has been proposed that emphasizes on socio-economic and techno-ethical dimensions of healthcare services for health and wellbeing.

Keywords: Ambient intelligence, Healthcare-IoT, EHR, Assistive ICT, Big data analytics SDG 3.4.

1. Introduction

Today, for the first time in history, most people can expect to live well into the sixties and beyond. By 2050, the population over the age of 65 will account for a sixth of the world's population, whereas in 2019 it was the one-eleventh of the world population. The biggest challenge in the future is to maintain mobility and promote healthy lives for the elderly. About 80% of older people will be residing in low- and middle-income countries (LMICs) by 2050 (see figure 1). The fastest increase of the elderly population (+225 per cent) is forecasted to happen in the least developed countries, rising from 37 million in 2019 to 120 million in 2050 [1,2].

According to estimates by the World Health Organization (WHO), there are more than a billion people across the world who need one or more assistive products, and most of them are the elderly and the disabled. Due to the ageing population and increasing NCD, the number of people in need of assistive products is expected to grow to more than 2 billion by 2050 [3,4]. It is now more important than ever to look for ways to encourage ageing or 'healthy ageing'. Assistive technology is the application of systematic knowledge and skills relating to assistive products that empowers the people to live with dignity [5,6].

Artificial intelligence (AI), like other sectors, has a wealth of expertise in healthcare to unlock new sources of development, change the way people work, and empower people to promote growth in the professional workplace. AI-oriented decision-making approach can free health professionals from routine tasks and save lives through early detection [7]. It is vital to make sure a certain level of understanding of the decision-making of AI systems. Explainable Artificial Intelligence (XAI) recently recognized as an extreme need to apply ML methodologies and extract knowledge from these models in real world applications with fairness, model clarification and accountability. Deep learning has also gained huge momentum in the field of machine learning, which is being implemented in all areas of human life [8,9].

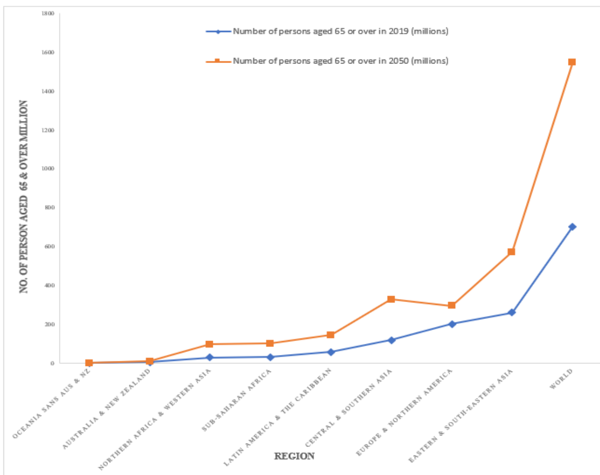

Fig. 1. Older population aged 65 and above in 2019 and 2050.

*E-mail address: raj9921@yahoo.com
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Fortunately, over the last decade, the proliferation of ICT has also been widely used, and it have been deployed and integrated into our routine activities, including the elderly. They primarily use ICT to restore or improve contact with the outside world, including communicating with loved ones and friends and finding information about health in order to achieve a higher quality of life. ICT enhances socio-emotional effects by helping older people overcome spatial-temporal barriers to empower them to maintain socio-cultural affairs [10-12].

Many EU and Asian countries have expanded their laws and regulations to allow for greater adoption of telemedicine systems, provide more guidance on digital medical technology and cybersecurity expectations, and widen the scope of reimbursement. As such, on March 9, 2020, the Ministry of Health allowed the French Health Insurance (NHI), by a signed decree, to reimburse all video counselling and tele-expertise for people with COVID-19 or its symptoms. Although telemedicine has been used sporadically in Indian healthcare in the past and had not been legalized, but taking into account the Covid-19 pandemic, the Medical Council of India has adopted the "Telemedicine Practice Guidelines", and on March 25, 2020, it was officially approved by the Ministry of Health and Family Welfare, Government of India [13-15].

Considering the emerging healthcare needs of older people and their sustainable socio-technical aspects this study focusses on "active ageing." This paper also discusses the need for influential and beneficial technologies to improve the lives of vulnerable people and to make these assistive technologies available to those in need. In this sense, a digital healthcare paradigm integrating wearable devices is presented here that also monitors health emergencies and emphasizes the socio-economic and techno-ethical dimensions of healthcare delivery.

The rest of this paper is structured as follows. Section 2 provides a literature review based on the technological influence on ageing society. Section 3 focuses on the methodology and significance of ICT-assisted healthcare paradigm for the older and vulnerable people. The discussion of the work included in section 4 and subsequently concludes the work with future scope.

2. Literature Review

When computers were in their early stages and out of the reach of the common public, numerous researchers [16-19] believed that the usefulness of computers would prove to be a milestone in the health sector. In addition, it has also been observed that in future computer costs would fall due to the wide availability of value systems that would support urban practitioners to provide health care services at remote location. Mills et al proposed a re-imagining of palliative-care access for promoting equitable results through public-health partnerships. It must be delivered through people-centred, integrated health services that pay particular attention to people's specific needs and preferences [20].

Kim et al mentioned the need to develop and implement new models of care that use technology to track critical physiologic and safety parameters [21]. Based on a 16-year longitudinal study in Melbourne, Kendig et al [22] reported the preference of Australian seniors' citizens for aging in place and the predictors of their subsequent experience. Through remote monitoring and enabling technologies, residential aged care facilities can be provided more proficiently than hospitals. Wang et al. [23] described the idea of smart home for the older people and the disabled as a promising and cost-effective way of improving home care, maintaining their health, and preventing social isolation.

Wearable devices and smart sensors can help institutional care facilities sense the movement of vulnerable patients. Meng et al. [24] found that elderly was more likely to experience positive changes in their healthy lifestyles after using e-health and mobile health technologies. Bhaskar et al. [25] focused-on importance of telemedicine services for the developing nations and discussed its progress during COVID-19 pandemic. The value of the global telemedicine market in 2018 was $38,046 million and is expected to increase to $103,897 million by 2024.

Ambient Assisted Living (AAL) is a subtype of ambient intelligence. Smith et al. [26] are optimistic about the future of assistive technology products and hope to expand the deployment of assistive technologies in LMICs. Li et al [27] emphasized the cognitive aspects of AAL to provide a better user experience. Calvin et al. [28] studied the magnitudes of association among childhood intelligence and all key issues of death by using entire year's birth population to follow-up to old age, thus capturing enough cases for each result. Here, longitudinal data demonstrate the role of child IQs in reducing the risk of death in the elderly from certain NCDs.

Koch [29] advised that social dimension must be completely understood, clinical preconditions should also be considered as well as viable technical solutions should be developed under the strict supervision of the legal and regulatory framework. Qadri et al. [30] presented cases for H-IoT in current medical systems, and described several other advantages of H-IoT that could substantially reduce the burden on public health institutions. Rahman et al. [31] introduced a secured, private, and explainable H-IoT-enabled sustainable health care framework.

Hashimoto et al. [32] pointed out that it is very important for surgeons to lay a foundation of AI knowledge of how it could affect healthcare and how they could interact with this technology. Bhatia & Sood [33] proposed a probabilistic health vulnerability prediction framework that enables the use of the artificial neural network (ANN) model, which consists of three phases, namely monitoring, learning and prediction. Dhagarra et al. [34] suggested that patients' fear of privacy loss must be dispelled in order to accept newer technology.

Li X et al. [35] highlighted the importance of design for security in the healthcare supply chain. Privacy is paramount in healthcare systems where sensitive patient information is constantly stored and continuously shared. As per various studies, information leakage is a common issue in health information systems. It is necessary to ensure that patients receive timely and accurate medical care in relation to the availability of services. Due to immutability property, blockchain technology has been introduced as a promising solution for EHR sharing with privacy and security preservation. Shamshad et al. presented a novel blockchain-based data protection and security preservation protocol for EHR sharing as well as improved diagnosis, and efficient treatments in telecare medicine information system [36].

3. Methodology

E- Inclusion, ICT, and assistive technologies that support older people who still live in their own homes can be a sensible solution to these challenges. Figure 2 focuses on sustainable integrated ICT services to promote their "healthy ageing", emphasizing the socioeconomic and ethical impact of digitization and technological progress. To ensure E-health, several key barriers must be overcome, such as access, installation, knowledge, design, data breach, privacy, integrity, and trust. Government, and non-governmental organization (NGO) should ethically fulfil four types of accountabilities, such as hierarchical accountability, legal accountability, professional accountability, and political accountability.

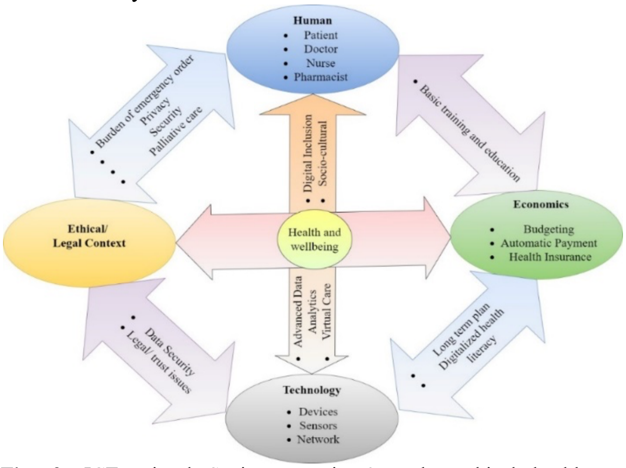

Fig. 2. ICT-assisted Socio-economic & techno-ethical healthcare paradigm.

Availability, acceptability, accessibility, accountability, affordability, and assessable are the caring attributes of smart healthcare that will bridge the gap between need and access in the future [37,38]. Successful inclusion requires that AI for health be designed to encourage the widest possible appropriate, equitable use and access, regardless of age, sex, gender, income, race, ethnicity, sexual orientation, ability, or other characteristics protected by human rights codes. Perceived usefulness, ease of use, trust, and concern for privacy have been shown to be direct predictors of patient behaviour in accepting technology when using healthcare.

According to the stipulations of the responsibility system, every citizen is accountable to the society and to one other, because everyone is closely related and affect each other's health. Unless citizens are aware of and actively fulfil their responsibility to interact with government social media platforms, ICT-driven practices will not provide better response. It has been seen that in health information system, big data refers to predictive analytics with machine learning platforms that provide sustainable solutions such as real-time alerting, treatment plans, as well as smart staffing and personalized medical services [39,40].

The biggest challenge now is to maintain mobility and healthy living of the elderly. Patients with cardiovascular disease can benefit from regular monitoring of blood pressure and heart rate at home. For cardiologists, it is convenient to use remote patient monitoring equipment outside the hospital to better track patients. However, it is important to consider factors such as usability, accessibility, and privacy when selecting the devices for elderly individual, particularly for those with cognitive impairments or other disabilities. Quality of sleep is a crucial characteristic of an ageing person′s health state. As we all know, emotions and psychological states can easily interfere with sleep. Sleep disorder is very common among elderly and affects many age-related chronic diseases, such as stroke, dementia, and cancer. In order to diagnose sleep disorders, monitoring polysomnography attending sleep technologist has become a gold standard [41,42].

In a wireless sensor network has been introduced to the record of physical data like heart rate (Pulse sensor), blood pressure (BMP180 sensor), and ECG (ADS1292R sensor) which is extensively used in the collection of vital signs [43]. It has also been described that using such a system to transmit accurate data between patient and physician can significantly reduce the number of physician and hospital visits with online prescriptions. It clearly shows that reducing hospitalized patients can greatly reduce costs [44].

Elderly health status can be obtained by constructing a home medical equipment system combining physiological indicator detectors namely weight scales, electronic blood pressure meters, clinical thermometers, oximeter, and blood glucose meters. In addition, sensors can be installed on household furniture and wearable devices such as smartwatches and pedometers to monitor and record the health status of the elderly, as well as timely health data to inform them about their physical health. By using physiological measuring hexoskin equipment may potentially become a non-intrusive manner to consistently assess the physiological measures in elderly with dementia, possibly suffering from behavioural and psychological symptoms [45,46].

3.1. Human activity recognition

Automatic recognition of physical activity, often referred to as human activity recognition (HAR), has become a key area of human–computer interaction (HCI) and mobile and ubiquitous computing research. HAR is the process of pattern recognition technology that automatically recognizes and classifies human activity based on data from wearable sensors. It has a wide range of applications in many fields such as healthcare, sports, security issues, and smart home automation. Movement is usually a typical activity performed indoors, such as walking, talking, standing, and sitting. It can be used to monitor and analyse activity patterns over time, identify changes or abnormalities that may indicate health or behavioural issues, and provide personalized feedback and recommendations to improve health [47,48].

3.1.1. Wearable health monitoring systems

In addition, wearable technology has been used to track patterns of sleep and physical activity in older populations. wearable devices example Fitbit, Oura Ring, Smart Sleep headband, Smartwatch, wrist-worn fitness tracker can greatly benefit elderly individuals by monitoring sleep patterns, identifying sleep disturbances, setting sleep goals, providing sleep coaching, and monitoring sleep medication. It is important to consider factors such as ease of use, comfort, and compatibility with other devices and apps when selecting a wearable device for sleep monitoring [49].

3.1.2. Remote patient monitoring systems

Remote patient monitoring means using the device to communicate between providers and patients outside of the provider's organization. In brief, RPM is an efficient way for doctors to accurately monitor a patient's chronic health status without the patient needing to visit the organization. Remote monitoring of patients target several sub-groups of patients, such as patients diagnosed with chronic illnesses, patients with mobility issues, or other disability, post-surgery patients, neonates and elderly patients. All these types of patients have conditions that are better to be monitored continuously. The aim of good healthcare is the ability to support ordinary life as much comfortable as possible to all patients [50].

Basic elements of a remote monitoring system are data acquisition system, data processing system, end-terminal at the hospital and the communication network. Data acquisition system is composed of different sensors or devices with embedded sensors with data transmission capability wirelessly. With the advancement of technology, sensors may not be medical sensors only; it could be cameras or smartphones. This is because, very recent research looks into contactless methods where the devices do not touch the body of the patient. Due to the availability of healthcare-IoT (H-IoT) enabled, safe, smart, and affordable sensors, healthcare informatics is undergoing a revolution. Thus, it brings us to the concept of smart home, in which various electronic devices are interconnected and provide better-quality two-way multimedia services [51,52].

In case of accidents and sudden injuries, the time they are monitored remotely could be effective response time they are being transferred to the hospital in an ambulance. E-Ambulance is the example of remote monitoring system of patients in an ambulance with the ability to monitor vital signs [53].

4. Discussion

Despite the growing numbers of frameworks, existing frameworks frequently cover only digital, ethical, and economical circumstances. Here, we followed more inclusive approaches and integrated services of ICT to facilitate "active ageing". It has been observed that the ageing process occurs with much physical, cognitive, psychological, and social change. Keeping in mind above-mentioned aspect, this study emphasizes the techno-socio-economic dimensions of sustainability, and integrate these with proposed ICT-assisted healthcare paradigm to promote sustainable integrated health services. The designed framework covers a synthesis of existing sets of principles articulated by multi-stakeholder organizations and eminent researcher from diverse discipline.

It has been observed two patients who successfully underwent laparoscopic high-anterior and low-anterior resections, respectively, through real-time telementoring with telestration, demonstrated the potential of the 5G network, and has obtained high satisfaction from the surgical team. The dawn of the recently developed 5G technology has made the concept of telesurgery a realistic option for patients requiring surgery over the next decade [54,55].

It has been observed that the optimism trait plays a favourable role in cardiovascular and endocrine systems, and their protective health effect may be particularly relevant in older adults [56-58]. Optimistic attitudes and positive emotions are essential for maintaining the mental health of the elderly. It has been found that older people believe that their spirituality is important for accepting loss, finding hope, and getting rid of fear, and their faith make them more active and enjoy daily life [59-61].

Numerous studies have shown that mental well-being and coping mechanisms are essential for people with debilitating and chronic illnesses. It is also important for Alzheimer's patients because it increases their sense of control over their progressive cognitive impairment [62-64]. The human sense of touch also performs an important interoceptive, affective care function, and it has been proven to be effective in relieving pain. As the senses begin to develop in the womb, touch is essential for the bonding between mother and infant, and is also important in later social life [65,66].

NCDs are also included in SDG target 3.4, which states that by 2030 reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being [67]. Figure 3 depicts the deadliest diseases that lead to the death of the elderly worldwide. NCDs are the major causes of poor health in the across the world, accounting for seven out of ten deaths worldwide. LMICs and at least those with lower socioeconomic status in high-income countries have higher mortality rates from NCDs, which makes NCDs a main hurdle to reducing health inequalities globally. Neurodegenerative diseases have become a vital public health problem around the world. According to statistics from the World Health Organization, 36 million people have Alzheimer's disease alone [68-71].

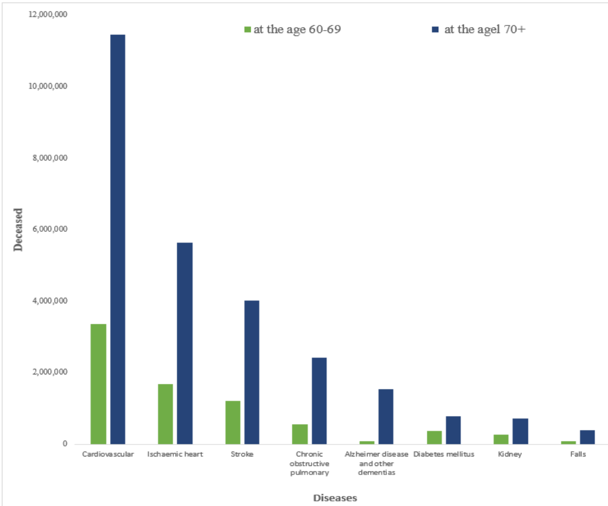

Fig. 3. The deadliest diseases that lead to the death of the elderly. Source: WHO Global Health Estimates.

Health waste or medical waste generated by health centers (hospitals, clinics, medical research institutes, pharmacies, private medical centers, morgues, autopsy centers and blood banks) is very diverse and more dangerous. Therefore, proper disposal of medical waste is essential to avoid environmental and health risks. Otherwise, environmental pollution and the proliferation of insects are almost inevitable, which can lead to the transmission of diseases (e.g. AIDS, hepatitis, etc.) to humans. About 16 billion injections are administered globally every year, but not all needles and syringes (Sharps waste) are subsequently disposed of properly [72].

The main cause of fatal injuries leading to hospitalization of the elderly is an increase in falls. It is the second leading cause of accidental death across the world. The risk of falls is about 15% for people over 65 years, and increases to 25% for those over 80 years of age. It is estimated that 40% of elderly patients admitted by fall disease cannot live independently, and about 25% will die within a year. Falls threaten the freedom of elderly population and cause a cascading effect on individual and socio-economic status [73,74].

Staying healthy for older adults can contribute to their families and communities in many ways. If senior citizens can experience these added years of life with healthy living and caring surroundings, their ability to cherish the things will be slightly different from that of a younger people [75,76]. The elderly plays an important role in providing unconditional and unpaid care for their spouse, grandchildren, and other relatives (including the disabled) [77].

It has also been observed that due to the COVID-19 epidemic, the world has undergone a radical shift in healthcare with a new shift towards RPM. Regulatory agencies, academia, and industry are encouraging smart home-based, portable, and wearable physiological devices as an increasing part of health care delivery. Wearable data also contributes to real-time behaviour change techniques such as timely adaptive interventions designed to dynamically assess user needs and deliver the appropriate amount and type of intervention at the appropriate time. It is expected that these measures will be effective in diagnosing, treating, managing, recovering, and rehabilitating diseases with minimal personal contact [78,79].

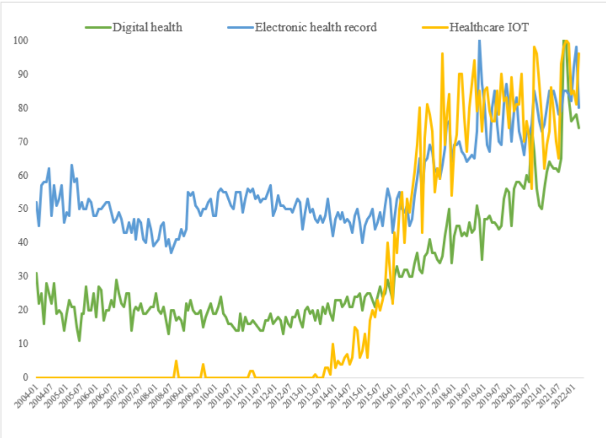

Fig. 4. Prevalence of digital health, EHR, and healthcare IOT from 2004 to 2022 (GT,2022).

Figure 4 shows the analysis of digital health, electronic health record and healthcare IOT using Google trends (GT). The search traffic provided by these trends is useful for detecting a specific phenomenon in a timely manner and is therefore an excellent monitoring tool that has been used in numerous publications [80-84]. Health sustainability is an essential paradigm for intellectual health promotion. An IoHT-based framework requires the use of security technologies for clinical data. In order to ensure sustainable healthcare facilities, data security has become a very relevant research area. Many researchers have proposed storing eHealth data on IoHT-based servers, which is important for security, privacy, and improved accessibility. IoHT is a network of sensors and devices connected via the Internet to collect, process, and analyze health data. This data can then be used for remote consultation, patient monitoring, diagnosis, and treatment [85].

It has also been observed that due to the COVID-19 epidemic, the world has undergone a radical shift in healthcare with the implementation of appropriate digital health technologies. Regulatory agencies, academia, and industry are encouraging smart home-based, portable, and wearable physiological devices as an increasing part of health care delivery. It is expected that these measures will be effective in diagnosing, treating, managing, recovering, and rehabilitating diseases with minimal personal contact [86,87].

5. Conclusion

In this study, we deeply analysed emerging techno-socio-economic aspects of health-related needs of the elderly, and proposed an ICT-assisted healthcare paradigm that emphasizes sustainable integrated services of ICT to nurture their 'healthy ageing'. In the context of public health risk, ICT-oriented communication can be effective, consistent, and sustainable only when the government and the public fulfil their responsibility to participate with the organization. It has been seen that AI through the convergence of the IoT and big data enables fast clinical data research, the early detection of cognitive decline, and the automation of clinical processes.

In addition to being transparent, the social functions that AI algorithms perform should also be predictable for those who govern them. There should be reliable protective measures to ward off cyber-attacks. It is a severe issue in all areas; however, it becomes particularly more important in healthcare as it has a direct impact on human life, and therefore reliable long-term protection measures are urgently needed. AI-enhanced health products, and services should always be combined with the UN SDGs and contribute to humanity and general well-being, defining the principle of human-centred AI in a positive and tangible way.

As AI technology are maturing and becomes more pervasive in our daily lives, there must be no biased to ensure inclusiveness. Without ethical AI, our human rights are at risk. So, a close transdisciplinary collaboration among government, computer scientists, medical professionals, health experts, researcher, and ethicists are essential for developing artificial wisdom technologies for human health and wellbeing. Promoting medical AI technology in rural areas of developing countries may be a means to alleviate the inequality of urban and rural health services. Appendix A highlights the analysis based on some distinct well-defined tools, emerging technologies, and neoteric methods to understand the ageing issues and addressing the possible solutions.

Ironically, poor data collection and systemic inefficiencies made it difficult to even attempt a scientific study of the erroneous rankings, so that the answers are accurate. There is a famous saying: “What is properly measurable can be improved.” In future, longitudinal monitoring of cognition across the lifespan will be beneficial to establish how their illness progresses and what influences the prognosis for NCDs prevention. More systematic longitudinal observational research is needed, focusing on the development of a person's life, physical activity and its relationship to other habitual factors. Further research could explore the extent to which attitudes toward integrated health-related technologies change as we age or as people become more and more familiar with enabling technologies.

Acknowledgements
The idea for this paper is inspired by my enthusiastic grandmother's problems and solutions in her later life, who received abundant care from her family. This type of health-related problem had been observed in other older adults and after extensive research and discussions with many older adults, this article has provided a new insight and solution. Finally, all authors are grateful to all dear elderly people who shared their life problems and views with us.

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