The global challenge of ageing population – Part I: Definitions, epidemiology and physiological changes

Ian Sammy¹, Joanne F Paul²
1. Consultant in Emergency Medicine, Scarborough General Hospital, Tobago
2. Lecturer in Emergency Medicine, The University of the West Indies, St. Augustine

Corresponding Author:
Dr. Ian Sammy
Consultant in Emergency Medicine
Scarborough General Hospital
Tobago
Trinidad & Tobago
Email:

Abstract

Background & Objectives
Over the past 50 years, epidemiological data from the World Health Organisation has demonstrated a trend towards population ageing throughout the world. While this is widely recognised in the developed world, the phenomenon has been largely overlooked in the developing world, despite the fact that the rate of ageing in developing countries far outstrips that of developed countries. This global trend towards an increasingly older society has significant implications for healthcare. This article aims to review the definitions of ageing, its epidemiological characteristics and physiological changes associated with ageing.

Methods
A narrative review of the literature was undertaken using Medline, CINAHL and the Cochrane Database, supplemented by manual searches of the literature, and guided by the reference lists of relevant papers identified in the electronic search. No restriction was placed on the type of paper to be included in the study.

Results
The initial electronic search of the three databases included 239 papers, of which 60 were found to be relevant and included in this review. These articles discussed the epidemiology and definition of ageing, the physiology of ageing and its impact on health and illness, and the implications for health services. The overall findings of the studies implicate the clear differences in the physiology of older people, which do create specific challenges for health service provision.

Conclusion
Population ageing is a significant global phenomenon, affecting both developed and developing regions of the world. More work is needed, particularly in the developing world, to better understand the impact of ageing on our population.

Introduction
The world’s population is ageing rapidly, and this has potential implications for health and healthcare. While this phenomenon has traditionally been considered a first world issue, evidence collected by the World Health Organisation over the past 50 years clearly shows that population ageing affects both developed and developing nations [1, 2].
Recent work from Trinidad and Tobago has confirmed the impact of ageing on medical and social support services, and the need for increased awareness among health and social care providers in the country. Older adults in Trinidad and Tobago report high levels of loneliness, and most of their social support comes from family members, a situation threatened by the erosion of traditional extended family structures in more recent times [3, 4]. Some local authors have highlighted the tendency towards more severe injuries and the increased rate of hospitalisation among older trauma patients in Trinidad [5, 6].

Recognising the importance of ageing to the planning and provision of health services, we undertook a review of the literature to determine the nature and extent of this phenomenon. This review article seeks to describe the definitions of ageing, the physiological changes associated with it in various organ systems as well as the global epidemiological characteristics of ageing with particular reference to healthcare access and the overall burden with respect to utilisation of resources.

Methods
A narrative literature review was undertaken to identify the evidence of the impact of ageing on health and illness. A research question was formulated using the 'PEO' format (population, exposure and outcome). The primary research question was:

“How does increasing age (exposure) affect health, illness and healthcare provision (outcome) in older people utilising the health services (population)?”

The primary aim of this review was to determine how differences in health and illness in older people affect the course of their illness and the provision of healthcare.

Secondary objectives included:
1. To identify the most appropriate definitions of ageing, as they relate to health and social care.
2. To determine the epidemiology of ageing in developed and developing countries, particularly in relation to healthcare utilisation.
3. To explore the physiological changes that occur with ageing, and describe how these impact on the presentation of illness in older people.

An electronic database search was performed on Medline (via Pubmed), CINAHL (via Ebsco) and the Cochrane Database. This was supplemented by a manual search of the reference lists of relevant papers from the initial electronic search.

No restriction was placed on the type of paper to be included, once these were pertinent to the aims and objectives of the review. However, the search was restricted to English Language publications and human studies.

Results
Of the 238 papers identified through the literature search, 59 were found to be relevant to this review. Nine (9) papers specifically discussed the definition of ageing, while 12 discussed its epidemiology. A further 18 papers described the physiological changes associated with ageing. Twenty (20) explored how the ageing process impacted on social care, health and disease.

Principal Findings
Definitions of Age and Ageing
Chronological Definitions of Old Age

Any discussion of the epidemiology of ageing requires a thorough understanding of the definition of the term. While the ageing of the population is self-evident to most observers, the definitions used to describe this phenomenon are not universally accepted or agreed [7, 8]. The simplest definitions of ageing have revolved around chronological age [7]. However, even this relatively straightforward concept has not found widespread agreement across different populations and societies. Definitions of ‘old age’ or ‘elderly’ have varied from as low as 50 years to as high as 90 years in different settings [8-10]. This discrepancy in definitions in part reflects real differences in populations; researchers in developed countries tend to use older age cut-offs for defining the elderly while those in developing countries (with lower life expectancies) define ‘old age’ as starting at a younger age [8]. These differences demonstrate the impact of ‘remaining life expectancy’ on the perception of ageing; ‘aged’ individuals are expected to have a relatively limited amount of life remaining, and of course the individual’s remaining life expectancy would depend on the average population life span [11, 12].

A good example of this is the definition of ‘aged’ used by the World Health Organisation. The WHO recognises that, while an age of 65 years is seen as the cut-off for ‘old age’ is seen as appropriate for most of Europe, North America and other developed world regions, this would not be appropriate for African countries where the average life expectancy in many countries may be as low as 60 – 65 years [9]. In this setting, a more useful definition of ‘old age’ would be 60 years or even 55 years in some communities.

Historical, social and legal considerations have also influenced our definitions of old age. The widespread use of 60 or 65 years to define old age can be traced back to work done by social scientists in Europe and North America in the aftermath of World War II [13, 14]. Most of these scientists, in the absence of an agreed age cut-off, used the pensionable age in their respective countries to define old age. Interestingly, Roebuck, in her 1979 paper titled ‘When Does Old Age Begin?’ argued that, at different points in history (and for different purposes), ‘old age’ has been defined as commencing anywhere from the 4th to the 7th decade [7]. As Roebuck illustrated, in the early Victorian era, social workers and philanthropists of the day regarded anyone above the age of 45 years as ‘aged’, particularly when considering the less economically fortunate members of society, such as the working classes in London’s East End. With the advent of a universal pension in the early 20th century, ‘old age’ was later pinned to this landmark, which was initially set at 55 years. As population health and life expectancy increased, however, so did the age of retirement; initially to 60 and then to 65 years for men [7]. Since Roebuck’s seminal paper, the retirement age in the United Kingdom and Europe has continued to rise, so that retirement for both men and women will be set at 67 years by 2020. In contrast, the retirement age for public sector workers in Trinidad remains at 60 years old, with an option to continue working until the age of 65 for men.

Multi-dimensional Definitions of Ageing

While we tend to view older people as a relatively homogenous group, there is a great deal of variability within this group [2]. In light of this, researchers have advocated a multi-dimensional approach to describing the ageing process, in which chronological age constitutes only one of many different parameters to be considered when assessing the age of an individual [11, 15]. Other characteristics of ageing that have been considered in this definition included biological age (utilising various measures of health and well-being); social parameters (such as functional independence); psychological factors (cognitive ability); economic factors (for example, the pensionable age) and remaining life expectancy [16]. The manner in which these diverse parameters are synthesized into a single concept of ‘age’ provides its own challenges. For example, while the shorter life expectancy in developing countries suggests that their chronological definition of ‘old age’ should be relatively earlier than in developed countries, in fact older people in these countries continue to contribute actively to the paid labour force well into their later years, and in this respect do not fulfil traditional socio-economic
The global challenge of ageing population – Part I: Definitions, epidemiology and physiological changes

notions of ‘older people’ as dependents of the state and their families. Some authorities have quantified this multidimensional approach to age and ageing, but these definitions are not generally used in the medical literature [11, 12, 15].

These diverse definitions of ‘old age’ are important to researchers. Several attempts have been made to standardise the definition of old age, but none has been universally adopted [8, 9, 17]. However, a chronological age cut-off of 65 years and older is increasingly used to define older people in medical research, and this is becoming the de facto universal definition of old age in medicine [9, 18].

The Epidemiology of Ageing

Global Trends in Population Ageing

Since 1950, the world has seen a significant increase in the age of its citizens. The rate and scale of this phenomenon is unprecedented in human history. Globally, the number of older people (aged 65 years and older) tripled, from approximately 180 million (approximately 1 in 16 people) to 600 million (approximately 1 in 10 of the population) between 1950 and 2000 and this number is set to triple again by 2050 to 2 billion. Thus, by 2050 nearly 1 in 5 of the world’s population is expected to be aged 65 or older. The current rate of growth in the older population of 2% per annum is predicted to continue well into the mid-21st century [2].

This growth in the older population has wide-reaching social, economic and cultural implications. The increase in the numbers of older people places an additional burden on working-age adults, on whom thee older people are likely to be dependent. The ‘potential support ratio’ or PSR (the number of individuals in a population aged 15 – 64, compared to those aged 65 and older) has decreased worldwide from 12:1 in the 1950s to 9:1 by 2000. It is expected to fall to 4:1 by 2050. This global statistic hides an even more severe reduction in this ratio in developed countries, many of which already have PSRs of less than 3:1 [1].

This increase in the number of older people increases the burden on healthcare. Older people are more likely to be affected by multiple chronic non-communicable conditions than younger adults and are at higher risk of complications from these conditions [19]. They are also more likely to be on multiple medications and to suffer drug-drug interactions than younger people [20-23]. Older people who present to hospital acutely unwell are more likely to be admitted and once admitted their length of stay is greater when compared to younger patients with similar conditions [24].

The Ageing Profile of the Developed World

While there has been an increase in the numbers of older people worldwide, these demographic changes have not been uniformly distributed. Increases in older people in the developed world have preceded similar changes in the developing world by several decades. Between 1950 and 2000, the proportion of persons aged 60 and older in developed nations increased from 12% to 20%, but stayed at 7 – 8% in less developed nations [1]. Developed countries also have the highest proportion of ‘oldest old’ people. At present 3% of the population of Europe and North America are 80 years or older; this is predicted to rise to 10% by 2050 [25]. This statistic has significant implications for health provision, as it is well recognised that these ‘oldest old’ individuals are more likely to suffer ill health, frailty and functional impairment than those aged 65 to 79 years [26].

Ageing in the Developing World

While changes in the age profile of the developing world have lagged behind those seen in the developed world, they should not simply be seen as mirroring what has already occurred in more developed settings. Since the beginning of the 21st century, the rate of ageing of the population in less developed regions of the
The global challenge of ageing population – Part I: Definitions, epidemiology and physiological changes

world has been significantly greater than in the developed world. By 2050, the rate of growth of the over 60s in the developing world will be 10 times that of the developed world. It is estimated that four fifths of the world’s older people (those 60 years and older) will live in the developing world by 2050 [25]. The lag in population ageing seen in the developing world can be attributed to temporal delays in improvements in housing, education, gender equality and health in these regions. All these factors are recognised contributors to the main drivers of population ageing, namely decreasing fertility rates, increasing proportions of the population living into old age and increases in individual life expectancy.

This anticipated shift of the older population from the developed world to the developing world may provide the developing regions of the world with a burden for which they are ill-prepared [27]. Many developing nations simply do not have the resources or infrastructure to cope with these changes in the same way as in the developed world. At present, much of the burden of social support for older people in the developing world comes from their families rather than from the state [3, 28, 29]. With the shift in demographics, the ‘potential support ratio’ or PSR (the number of persons aged 15 - 64 compared to those aged 65 and older) is set to decline in the developing world, thus making it less likely that family support will remain an effective source of social support for older people [2]. Healthcare systems and social services in many parts of the developing world are under-resourced and unlikely to be able to cope with any significant increase in demand from an ageing population.

Work by Rawlins et al and Moonesar et al in Trinidad have confirmed the impact of ageing on social support in our local setting. Both authors describe an increasingly isolated older population still highly dependent on a dwindling family support structure [3, 4]. However, on a wider scale, there is a paucity of research into healthcare utilisation by older people in the developing world, so the full impact of the ageing population on health services in the developing world is not well understood [30].

The Physiology of Ageing

Ageing and Illness

The physiological response to illness and injury differs significantly between older and younger people, and has implications for health and social care. In general, healthy older people have physiological parameters broadly comparable to their younger counterparts in the resting state, but may respond differently to acute stresses, such as illness or injury [31, 32]. In particular, the physiological reserve (the maximal ability of the body to respond to physiological stressors) is often diminished in older people [31-34].

Ageing and the cardiorespiratory system

Changes to the cardiorespiratory system with normal ageing can have a profound effect on the individual’s ability to respond to physiological stressors. Structural changes to the heart include an increase in ventricular size, but a decrease in the number of myocytes, leading to a decrease in ventricular compliance and alterations of diastolic ventricular function; the heart is thus less effective at refilling after each contraction. In addition, degeneration of the autonomic nerve supply to the heart leads to an increase in resting heart rate in older people, while decreased compliance of peripheral vasculature is associated with an elevation of mean arterial pressure. While there is no change in resting cardiac output in healthy older people, their ability to respond to physiological stress (such as blood loss) is blunted by as much as 20% to 30%, due to a reduction in the ability to increase both stroke volume and heart rate when required [31, 35]. In addition, any increase in stroke volume is mediated through an increase in diastolic filling, rather than an increase in ejection fraction as seen in younger individuals, and this increases the risk of diastolic heart failure in older people [31]. Finally, the decreased vascular compliance in older people reduces the ability for peripheral vasodilation in response to
tissue hypoxia; thus in conditions of poor tissue perfusion, such as shock, older people are more likely to suffer from hypoxic end organ damage than younger people [35].

Respiratory changes with age include a decrease in chest wall compliance, a gradual loss of pulmonary structural tissue and a reduction in the surface area available for gas exchange. These changes lead to a gradual increase in air trapping, and a decrease in vital capacity as well as a decrease in gas exchange in the lung. Resting respiratory minute volume is identical for older and younger people of comparable height, weight and gender. However, the ability to respond to increased respiratory demand (for example during exercise, or in situations of hypoxia or sepsis) is greatly reduced with age (32). There is also a blunting of the normal responses to hypoxia and hypercapnia in older people, so that for any given level of respiratory compromise, older people show less signs of distress.

Age-related declines in respiratory epithelial function along with weakening of respiratory muscles and alterations in cellular immune function within the lungs reduce the older patient’s ability to clear lung secretions and deal effectively with the threat of lower respiratory infection [32]. These changes mean that older people are more susceptible to chest infections, which can be exacerbated by chest injury, altered consciousness and immobilisation [36].

Ageing and Neuropsychiatric Function
Among the various changes in organ function observed with increasing age, changes in neuropsychiatric functioning are of considerable concern to researchers, clinicians and patients. There are concerns among health professionals about the level of services required to care for an increasingly older population with high levels of cognitive dysfunction [37]. Many researchers have identified declining cognitive function, including changes to memory, comprehension and decision making, as a part of normal ageing. Both long term and short term (working) memory decline with age [38, 39]. Other cognitive functions are also affected; speed of cognition is reduced, as is inhibition. Finucane et al demonstrated that, while comprehension and everyday problem solving are not necessarily affected by age, older people are less able to make decisions when presented with more complex information. In these situations, they take longer to make decisions and these decisions are less likely to be internally consistent [40].

Several authors have also recorded a significant decline in neurocognitive function following acute illness and hospitalisation. Ehlenbach et al observed a loss of cognitive function following admission for acute illness in older patients which was more marked in the oldest subjects [41]. Other studies have demonstrated poor levels of functional recovery in older patients with stroke and head injuries [42, 43]. In summary, research into neuropsychiatric function and ageing suggests that there is a gradual decline in certain aspects of neurological function with age, which may be accelerated by acute intercurrent illness and hospitalisation.

Age related changes to the structure and function of the brain are of particular importance in relation to brain injury. Age related brain atrophy increases the potential subdural space, so that expanding space occupying lesions, such as intracranial haematomas, have more space into which they can expand before the effects of increased intracranial pressure are manifest. Older people therefore tend to have a higher Glasgow Coma Score (GCS) for any given severity head injury, compared to their younger counterparts [44]. Because of this, serious head injuries are more likely to be missed in older patients and the GCS is a far less reliable indicator of head injury severity in this age group [45]. In light of this, it is important to have a lower threshold for intervention in older head injured patients, particularly those on anticoagulants. More recent iterations of some international triage scales, such as the Canadian Triage and Acuity Scale (CTAS) recognise this and have thus included age as a modifier in head injured patients.
The global challenge of ageing population - Part I: Definitions, epidemiology and physiological changes

Ageing and the musculoskeletal system

Physiologists have for some time been aware of the loss of muscle mass that occurs with normal ageing, termed ‘age-related sarcopenia’. Both men and women lose muscle mass, muscle strength and muscle quality with increasing age; by the 7th to 8th decades, there may be a 20 – 40% decline in muscle strength compared to younger adults and this can rise to as much as 50% in those aged over 80 years [46]. The impact of sarcopenia in older people is significant, as it decreases functional independence and increases the risk of falls. While regular resistance training can attenuate the loss of strength and muscle mass seen in later life, it does not completely eliminate it [47, 48].

In addition to loss of muscle mass, older people also lose bone density and joint mobility [49-51]. The net effect of all these changes is that older people are more likely to fall, and when they do fall, they sustain more serious injuries than younger people, often requiring hospitalisation [52]. In Trinidad both Yogi et al and Naraynsingh et al demonstrated that older fallers in the Southwestern Regional Health Authority catchment area suffered more severe injuries, and required hospital admission more frequently than younger fallers [5]. In addition, Yogi showed that falls in older people who had fallen suffered more severe injuries than patients of the same age who had injured themselves by mechanisms other than falls [53].

Other Effects of Ageing on Human Physiology

There is a 0.5% annual decline in glomerular filtration rate after the age of approximately 20 years [54, 55]. In later life this leads to a significant decrease in the kidney’s ability to excrete toxic metabolites and drugs, and to maintain electrolyte, acid-base and fluid balance. In addition, the reduction in the total number of nephrons in the kidney also decrease its ability to concentrate urine and maintain normal biochemical balance in times of physiological stress, such as in shock and dehydration [54]. There is also a decrease in size of the liver and the rate of live blood flow with age [56]. This may affect older patient’s ability to neutralise toxins and drugs, though this effect has not been consistently demonstrated by researchers [55].

Temperature regulation is also affected by age. While the baseline core temperature for healthy older adults is not different to younger adults, they respond differently to cold and heat stress. Older adults are more likely to lose heat when exposed to cold stress. This effect is more pronounced in older men compared to older women, who are thus particularly vulnerable to hypothermia [34]. The regulation of skin blood flow (an important mechanism for losing body heat) may also be compromised with increasing age. While this does not affect heat regulation in healthy subjects, unwell older patients are unable to maintain stable core body temperatures on exposure to heat. These would include dehydrated patients and those on medication that may alter the temperature regulation mechanisms of the body. Thus, older people are more susceptible to heat stroke at high ambient atmospheric temperatures [34].

Frailty and Ageing

The physiological decline associated with ageing, along with an increase in chronic illness, alterations in mental status and social vulnerability in many older people has led to the concept of ‘frailty’. The British Geriatric Society has defined frailty as

“...a distinctive health state related to the ageing process in which multiple body systems gradually lose their in-built reserves” (Fit for Frailty - British Geriatric Society)

Frail adults have a lower level of functional capacity than healthier patients of the same age, are more likely to suffer acute illnesses and injuries and when they do are less likely to recover to their premorbid level of functioning. Frailty can thus be seen as a slow and progressive decline in health status, functional capacity and
social independence that often accompanies the ageing process, but is not inevitable [57, 58]. In addition, the rate of decline varies widely from one individual to another [59]. Frailty has been shown to be an independent predictor of mortality and functional capacity in patients suffering many different acute challenges, including serious injuries and illnesses as well as hospital admission [60].

Conclusion
In conclusion, this paper has explored the definition of ageing, reviewed the global epidemiology of ageing and the physiological changes that occur with increased age. While researchers into this phenomenon have struggled to agree on a universally accepted definition of ageing, there is no doubt that the world population is getting significantly older. Of concern, the rate of this global phenomenon of population ageing is happening at its fastest in the developing world, where governments, policy makers and healthcare providers are least prepared to deal with it.

Population ageing is of great importance to all healthcare providers, as the changes in the physiology of older people make them less able to respond to acute physiological stress, and this increases their risk of ill-health while decreasing their ability to respond to such insults. This in turn places greater demands on health and social services, which may be ill-equipped to deal with such demands in developing countries. A better understanding of the health of older people in the developing world, and their utilisation of health services will allow these countries to prepare for the impending ‘silver tsunami’ on the horizon.

References
The global challenge of ageing population – Part I: Definitions, epidemiology and physiological changes

29. Dressler WW, Balieiro MC, Dos Santos JE. The Cultural Construction Of Social Support In Brazil:
The global challenge of ageing population – Part I: Definitions, epidemiology and physiological changes

50. Runge M, Hunter G. Determinants: Of Musculoskeletal Frailty And The Risk Of Falls In Old Age. Journal of