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Scientific progress and longevity: curse or blessing?

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Background: life, death and the elixir of long life

Many myths and epics, from various eras and geographic locations, mirror the human yearning for longevity. The Asian Epic of Gilgamesh is one of the oldest (2600–2500 BC), but there are many others: the Garden of Eden (in the Bible), the Holy Grail, the Fountain of Youth, the Philosopher's stone, to mention just a few. Many 'precursors' of modern scientists actively sought to find medical means to defeat death (a notable example is the alchemists, particularly the Chinese alchemists in the fourth and third century BC). In some sense, it may be argued that much, if not all, scientific effort is ultimately meant to prolong human life, the life of the planet, to give humans and perhaps other living beings the best chance to live as well as possible for the longest time, hopefully forever. Many of those who defend scientific freedom do so in the name of human welfare, longevity and freedom from illness and disability (see Chapter 15 in this volume).

The longing for immortality is obviously the other face of the anxiety about death. The finitude of human existence is at the heart of Western philosophy across the centuries. As Lachmann (see Chapter 1 this volume) points out, the awareness of death is probably exclusive to humans among all the animals, and this has probably prompted the birth of theist religions that promise some kind of afterlife or reincarnation. Many philosophers and schools of philosophy since antiquity have also attempted to ease worries about death. The Eleats believed in an eternal reality, from which we come and towards which we are directed. Life is a passage in an uninterrupted journey. Later, in Plato and much of the Platonic tradition, death acquires a positive value; through death the soul will be finally freed from the 'cage' of the body. Plato, in his *Apology*, writes:

> Either to be dead is not to exist, to have no awareness at all, or it is, as the stories tell, a kind of alteration, a change of abode for the soul from this place to another. And if it is to have no awareness, like a sleep when the sleeper sees no dream, death would be a wonderful gain. (1984: 103)

Epicurus expanded on the idea that death represents the end of sensations, including good and bad:

> Accustom yourself to believe that death is nothing to us, for good and evil imply awareness, and death is the privation of all awareness; therefore a right understanding that death is nothing to us makes the mortality of life enjoyable, not by adding to life an unlimited time, but by taking away the yearning after immortality. For life has no terror; for those who thoroughly apprehend that there are no terrors for them in ceasing to live. Foolish, therefore, is the person who says that he fears death, not because it will pain when it comes, but because it pains in the prospect. Whatever causes no annoyance when it is present, causes only a groundless pain in the expectation. Death, therefore, the most awful of evils, is nothing to us, seeing that, when we are, death is not come, and, when death is come, we are not . . . The wise person does not deprecate life nor does he fear the cessation of life. (2017)

In spite of these (and other) efforts to calm uneasiness at the thought of dying, aversion to death is quite pronounced in humans and drives much of our individual and collective efforts. Contrary to what Epicurus may have hoped, humans have continued across the centuries to fight death and deadly diseases, and to extend and ameliorate their quality of life.

Science, including medical science, developed and changed drastically during the Renaissance: Kepler, Copernicus, Newton, Da Vinci, Vasalio, Descartes and many others revolutionised the understanding of the universe, of humankind and of other animal kingdoms. The changed landscape paved the way for the great discoveries and innovations of the second part of the 1800s and of the 1900s.

Science has had a significant impact upon longevity: Lachmann highlights that the main determinant in the reduction of mortality since the 1900s has probably been the development of epidemiological science, which has allowed control of infectious diseases (see Chapter 1 in this volume). There is wide agreement among demographers as to the factors that have extended human life: tackling infant mortality, particularly through the mastery of infectious diseases, was one of the most important in the second part of the 1800s. During the following century, biomedical sciences also tackled much better the diseases of older people, particularly cardiovascular diseases. Improvement in living conditions, provision of clean water and sewage disposal, better nutrition, better education, better income and better medical care have all contributed to doubling life expectancy in just over a century, initially more prominently in middle- and high-income countries (Bonicelli and Sciarretta 2005), and now across the globe (WHO 2015a). Among all these factors, it seems that the contribution of science and medicine, through immunisation, vector control and provision of drugs, is probably the most substantial (Gratton and Scott 2016: 19).

Moreover, cellular and genetic therapies offer the possibility of treating or preventing many serious diseases and extending human life further.

Transplantations, now seen as established treatment, were only developed in the 1960s, and give us the opportunity to substitute old or damaged body parts with younger and healthier versions; genome editing revives the prospect of xenotransplantations. Cellular therapies can regenerate tissues, and if genetic and cellular research realised its potential, many degenerative diseases could be cured or even eradicated from humankind, with the result that we all could potentially live longer and disease-free lives.

There is further ground for optimism for the non-Epicurean. At the end of the 1990s it was discovered that lifespan depends on the bottom part of the chromosome (called the telomere), which protects the genetic material (Bodnar et al. 1998). Every time the genetic material is replicated during cellular replication, the telomeres become shorter, and thus they lose part of the genetic information they carry. Ageing is determined by this process, and this process ends when the cell has lost all the genetic material, cannot replicate itself and dies. A gene is responsible for the initial length of the telomeres and for the rhythm of shortening. Therefore, in principle, intervening on the length of the telomeres either with drugs or by genomic therapy could extend human life, in principle forever (accidents and illnesses aside). The hypothesis that human life could be extended indefinitely is contentious: a 2016 article published in *Nature* denies that this could ever be possible (Dong et al. 2016), but experiments on non-human animals show that this type of intervention may reverse the process of ageing (Broccoli et al. 1997).

Immortality may not yet be on the menu for us, at least not on this earth, but we live longer than the previous generation, and the next generations will live longer than us. This offers us hope for a long life, and is perhaps the fulfilment of one of our most ancient and rooted dreams. But, as we all know, the sweetest of all dreams can easily turn into the worst nightmare.

Introduction

Today men live on average 76 years and women 83, and average lifespan extends itself by about three months every year. According to some studies people will soon live on average 120 years, and adolescents today have a life expectancy of 100 years (Bonicelli and Sciarretta 2005). In the UK, by 2040 one in seven people will be aged over 75 (GOS 2016). A real demographic revolution is thus well under way. This raises a number of questions and concerns. Some are metaphysical in nature: longevity raises questions about what it is to be human. If finitude is an inherent feature of humanity, how long can our life be before we become *something else*?

Biomedical sciences also raise metaphysical issues. Think of transplantation: naturally we know that nearly all our cells are replaced regularly, so in one sense it shouldn't worry us that bigger body parts are replaced. But how many parts of 'me' need to be substituted before 'I' become 'someone else'? Are there some specific organs that are constitutive of personal identity?

The heart, or the brain, or something else, or nothing? Would I still be me in some significant sense, if, for example, my body parts (some or all) were replaced regularly, every 50 or 60 years, say? And how about replacement with other animals' body parts, or with artificial parts? What is 'I' a function of? Of the way I look? The face I have? The skills I have? The materials I am made of? The memories I hold? Would I still be me if I had, say, a brain replacement, or if my vital organs were not made of organic material? Or would I be someone else? (Bonicelli and Sciarretta 2005).

I will not discuss in this chapter the metaphysical issues relating to what it is that makes 'you' and 'I' respectively *you and I*, and what it is that constitutes the essence of personal identity. One of the reasons for leaving the metaphysical questions aside is that in the debate about ageing and longevity, these metaphysical issues are sometimes used simply to contradict the value of science. For example, it is sometimes argued that to strive for longevity and immortality is to deny *the dignity* of humankind as it is (Ramsey 2009). The appeal to the metaphysical issue of what a 'human' is thus is used ad hoc in a non-elaborated attempt to discredit certain practices.

Another similar objection to science, which I will not consider here in any depth, is the one that argues that the attempt of biomedical sciences to eradicate diseases is an attack on the dignity and value of people who have those diseases. This is a particularly common argument with regard to genetic testing, particularly prenatal genetic testing, genome editing and mitochondrial DNA replacement. For example, some see prenatal genetic testing for chromosomal disorders as an attack on the dignity of people born with Down's syndrome – and similar arguments apply to other conditions as well (BBC 2016). An in-depth response to these concerns would require a separate analysis, but it is sufficient to note here that there is no reason why achieving a longer lifespan should imply the ascribing of less dignity to those, or those generations, who have not been lucky in the same way; similarly, attempting to eliminate certain diseases, or supporting science to do so, in no way involves undermining the dignity of people who are born with or have developed those diseases. One can consistently believe that it is not immoral (or that it is indeed good) to attempt to cure or even eliminate cancer, dementia, spinal cord diseases and many others, while recognising the equal dignity and value of people who suffer from those conditions.

I will thus leave aside the metaphysical issues relating to personal identity, or arguments suggesting that science, particularly biomedical sciences, represent an attack on human dignity. I will instead focus on the practical and ethical concerns surrounding longevity: how is society going to cope with an increasing number of long-lived people? Greater numbers of older people in society may mean an increase in dependency, infirmity, dementia epidemics, medical spending. Will the workforce cope with the increasing demands of the older sections of the population?

The implications of population ageing are vast: they spread to housing, pensions, family life, family responsibilities, transport, education, working patterns and healthcare systems (GOS 2016). The 'sweetest of all dreams' can easily mutate into a looming crisis. The worries are wide-ranging: levels of ill health and disability will increase, the workforce will become increasingly reduced, and chronic conditions, multiple morbidities and cognitive impairments will become more common, raising long-term expenditure to unknown levels. At the same time families will face increasing pressure to balance care with other responsibilities, particularly work. As the population ages, so will the workforce: how can the nation's economic well-being be preserved? (GOS 2016).

I suggest that the demographic changes are inevitable and irreversible; but they are not a curse: they are to be welcomed as one of the greatest triumphs of humankind (WHO 2002a: 6). Many worries surrounding longevity (of individuals and of our species) result from a misconception of old age as a season of dependency and burden, on persisting stereotypes of the old as frail and useless, and on misunderstandings relating to disease and old age. Moreover, many important steps can be taken to prevent certain negative outcomes from materialising.

The demographic revolution: facts and myths

In the last century the world has faced a real demographic revolution. 'In 2010, an estimated 524 million people were aged 65 or older – 8 per cent of the world's population. By 2050, this number is expected to nearly triple to about 1.5 billion, representing 16 per cent of the world's population' (WHO 2011). The main drivers of this ageing population are an increase in life expectancy and a decline in fertility and birth rates. Estimates for 2014 predicted that over the entire world, the number of over-sixties will double from approximately 11 per cent to 22 per cent between 2000 and 2050 (WHO 2014). Already in 2015, it appeared that people over 60 represented over 30 per cent of the population in Japan, and this proportion is predicted to grow over 30 per cent in many more areas of the world (WHO 2015a).

> The absolute number of people aged 60 years and over is expected to increase from 605 million to 2 billion over the same period . . . The number of people aged 80 years or older will have almost quadrupled between 2000 and 2050 to 395 million. There is no historical precedent. (WHO 2014)

The *fastest* increases are predicted to occur in low- and middle-income countries. For example, in China the number of those over the age of 65 is likely to increase to 330 million by 2050 from 110 million in 2011, and by then there could be 100 million people in China over the age of 80 (WHO 2011). For countries in which the demographic changes occur quickly,

giving less time for adjustment, the strain on national infrastructures, especially the national healthcare systems, is likely to be significant.

Ageing populations are at the centre of debates on social and economic life. As Weisstub puts it: 'Longevity coupled with economic reality is a frightening cocktail for societies to bear' (2015: 150). Phillipson adds:

> Concerns about the most appropriate way of resourcing such populations, their impact on standards of living, and relations between age groups and generations feature prominently in public debate and discussion. The 21st century will without question be a time when all societies take stock of the long-term impact of demographic change and the implications for managing and organizing a major area of social and economic activity. (2015: 80)

Western governments have considered population ageing as 'a mixed blessing' (Phillipson 2015).

Longevity raises a number of ethical, social and political issues as well as issues of global justice. Will the labour force be able to assist the ever-growing proportion of older people? Will healthcare systems be able to cope with the demands of a long-lived generation? It also raises ethical and political issues of intergenerational and global justice: what do we owe to future generations? And what do we owe to each other globally? Until 2000, the European Union did not express particular concern over the ageing population. For example, in the OECD document *The Welfare State in Crisis* (cited in WHO 2000), the issue of long-term care was given only marginal coverage. Later, however, especially in the last decade, the WHO has been increasingly worried about demographic changes and the ability of states to cope.

However, a few points need to be clarified. Many older people continue to work in either the formal or informal labour sectors (WHO 2002a; 2012). Moreover, the productivity of the older person, overall, does not seem to be lower than that of younger workers; in fact, according to some studies, older workers are more efficient than younger workers (Russo et al. 2006; Heidemeier and Moser 2009; Staudinger and Bowen 2011; Backes-Gellner and Veen 2013). Experience, knowledge and insight may compensate for some of the losses that may accompany ageing (these and others will be discussed later).

It should also be noted that people after retirement age often take responsibility for household management and childcare, which allows younger adults to work outside the home. In this way, they contribute actively to the labour market. Older people often offer the skills and experience accumulated during their working life in the voluntary sector, acting as volunteers in schools, communities, religious institutions, business and health and political organisations (WHO 2002a; 2012). Many long-lived people, then, far from being a 'burden' on society, provide an important contribution to the fabric of society, and ultimately benefit the overall

economy. However, it is a contribution that, not being always directly remunerated and thus not being directly a part of the complex financial system of paid labour, tends to be overlooked, and its value therefore tends to be underestimated.

There is another aspect that is noteworthy: Gratton and Scott (2016) propose a number of solutions to the issue of sustainability. They note that the three-stage life (education/working life/retirement) was relevant when average life expectancy was around 70 years, and is no longer relevant when people can expect to live well beyond 100 years. Therefore, the structure of life, and working life, needs changing. We will all need to work much longer, and this seems inescapable; but working patterns will also need to change – for example we will have to retrain later in life, as the skills acquired during our earlier years may be obsolete during our seventies and eighties, and it is likely that the working environment will also become more flexible. Interestingly in this context, Gratton and Scott note that science will be one of the sectors that are likely to obtain an increment as the population ages:

> Greater numbers of older people will create a demand effect to which sectors and market prices will respond. So, for example, it is likely that medical research focused on longevity and bioengineering will be significant growth sectors and the service sector will shift towards healthcare and service provision.
>
> Environmental concerns and sustainability will also exert a substantial impact on prices and resources and the relative size of different sectors. We are on the cusp of substantial shifts in energy provision and, if energy scarcity continues and energy prices rise, then there will be significant innovations in energy creation and resource conservation. The same is true of food supply, where there is an expectation of radical innovation especially in combination with genetic engineering and health concerns. (2016: 50–1)

The next section will look at the issue of healthcare needs, because one specific concern relates to the ability of the healthcare system to cope with the demands of an ageing population (OECD 2006). I will evaluate the changes in disease patterns that appear with increased longevity, and I will argue that these changes need to be understood. We will see that several diseases typically associated with old age are not an inevitable consequence of age, and there is a lot that can be done by individuals and collectively in order to reduce their incidence.

Longevity and healthcare

Becoming older, as is well known, exposes us to some ailments. The greater the number of older people, one may believe, the greater the demands on healthcare systems. However, whereas it is undeniable that older people may have greater healthcare needs than younger people, the relationship

between longevity and *healthcare requests* or *healthcare access* is not linear.

First, not all older people are unhealthy, and not all young people are healthy; health needs are highly variable within individuals, and not just within age groups. But even if it were true that older people (say the group over 60) have greater healthcare needs than younger people, it does not follow that they actually *demand or access* the healthcare system; their needs thus do not automatically translate into spending. For example, in low- and middle-income countries the increase in healthcare needs does not result in higher demand on the healthcare system, due to a number of factors, including barriers to access (WHO 2015a). Also, in high-income countries, research shows that those with chronic conditions tend to use more healthcare than those who do not have these conditions. But among those with chronic conditions, people with additional functional limitations use healthcare services more than any other group. So, there are variations among individuals *and within groups*. Moreover, even in high-income countries, where there may not be particular barriers to access to healthcare services, people with lower socio-economic status tend to access healthcare less than other groups, regardless of their needs (Alecxih et al. 2010; Terraneo 2015).

It is thus extremely difficult to predict the impact that population ageing has or will have on healthcare expenditure. Even if barriers to access and social inequalities were to be eliminated, so that healthcare access and demands matched healthcare needs, the link between longevity and healthcare expenditure is not linear (WHO 2015a).

Recent research indicates that in high-income countries the peak of healthcare demands is around the age of 65–70; after that time demands decrease (Oliver et al. 2014; Kingsley 2015). Historical analyses also suggest that ageing may have less influence on healthcare expenditure than other factors. Research conducted in the US between 1940 and 1990 found that ageing

> contributed to only around 2% of the increase in health expenditures observed during the period. In comparison, technology-related changes in practice were responsible for between 38% and 65% of growth, increasing prices were responsible for between 11% and 22%, and growth in personal income was responsible for between 5% and 23%. Similarly, research on expenditures in France between 1992 and 2000 found the contribution of ageing to be relatively small, with the impact of changes in clinical practice being almost four times as large. (WHO 2015a: 96)

Therefore, the claim that population ageing will result in increased healthcare expenditure is simplistic.

A related worry is that population ageing is correlated with changes in disease patterns, and this in itself poses novel challenges for healthcare systems. While this is true to an extent, the relationship between these changes and longevity needs to be understood.

Disease patterns and longevity

In a 1998 document, the World Health Organization (WHO) reported that changes in the population structure affect disease patterns (WHO 1998a). The WHO lamented that what it called *non-communicable diseases* (NCDs) have become the leading causes of death both in 'industrialized countries' (WHO 1998a: 14) and 'developing countries' (WHO 2017). The main NCDs listed in 1998 were (WHO 1998a: 14):

- cardiovascular diseases;
- hypertension;
- stroke;
- diabetes;
- cancer;
- chronic obstructive pulmonary disease;
- musculoskeletal conditions (such as arthritis and osteoporosis);
- mental health conditions (mostly dementia and depression);
- blindness and visual impairment.

In 2002 the WHO again reported that NCDs may be significant and costly causes of disability and reduced quality of life (WHO 2002a: 34), and can be expensive to treat and long-lasting (WHO 2002b).

More recent research, however, amends the picture significantly:

- NCDs kill more than 36 million people each year.
- Nearly 80 per cent of NCD deaths – 29 million – occur in low- and middle-income countries.
- More than nine million of all deaths attributed to NCDs occur before the age of 60; 90 per cent of these 'premature' deaths occur in low- and middle-income countries.
- Cardiovascular diseases account for most NCD deaths, or 17.3 million people annually, followed by cancers (7.6 million), respiratory diseases (4.2 million) and diabetes (1.3 million).
- These four groups of diseases account for around 80 per cent of all NCD deaths.
- They share four risk factors: tobacco use, physical inactivity, the harmful use of alcohol and unhealthy diets (WHO 2017).

This research shows that NCDs are *not* diseases of the elderly and are not a result of longevity. They may afflict all sections of the population, regardless of age. In higher-income countries they are more often associated with old age, either because people tend to become affected later, or because people live for longer periods with their disease, due perhaps to better healthcare and better living conditions (Kalisch et al. 1998: §7.1). Moreover, NCDs

are to a large extent preventable, and many prevention measures are highly cost-effective. Thus, again longevity and population ageing will not necessarily result in an increase in healthcare demands and expenditure (WHO 2002a; 2010).

As mentioned earlier, health and illness are highly subjective states, and it is simplistic to associate longevity with disease. However, it could be objected that as we age, we are subjected inevitably to a certain degree of molecular and cellular damage. This damage may result in functional impairments, which, in turn, may cause psychosocial afflictions (WHO 2015a). While this is true, it is also to be recognised that how susceptible individuals are to those losses, and how they respond to them, is subjective, and much can be done to prevent these losses, or to prevent a deterioration in people's quality of life once they have taken place.

We have seen that there are various factors that are responsible for the onset of NCDs; these diseases are not age related, and are much more directly correlated to behavioural, psychological, social and environmental factors than to chronological age. Tobacco smoking, for example, increases the risk of stroke and lung cancer, accelerates the decline of bone mineral density, muscular strength and respiratory capacity, and so may lead to important losses of functional capacity. Excessive alcohol consumption and a diet high in saturated fats and salt and low in vitamins and fibre are also associated with higher risk of cardiovascular diseases. From a psychosocial point of view, both decline in cognitive capacity and the sense of loneliness are often related, in the older person, to the loss of relatives and close friends. In their turn, lack of participation in activities and social isolation are related to a higher risk of disability, both physical and mental. These factors can be modified, and they do not automatically 'come with living longer'.

In what follows I will look specifically at the ailments that are often thought to be related to old age, and argue that the connection between these and longevity is not necessary: in fact living longer does not necessarily expose us to certain diseases. It is often other factors that do so, not primarily age. I will focus in particular on the relation between physical activity and NCDs. However, this should not be misinterpreted. What I point out does not gesture towards assigning individuals the sole or main responsibility for their own ill health. I simply point out that age is not primarily responsible for many NCDs, and that these are largely controllable and preventable. But whether or not individuals are in a position to make lifestyle changes or to exercise sufficiently for their health is not only a function of their conscious choices and will. Whether or not people are able to exercise depends on many factors (working patterns, family responsibility, costs, accessibility, information and infrastructures). Later in this chapter I will discuss some key actions across sectors that may reduce barriers to healthier longevity.

Musculoskeletal damage

A condition that afflicts older people more than other groups is musculoskeletal problems. There are various types of musculoskeletal problems and various degrees of impairment. However, it is well known that older people are, for example, subject to falls more than other age groups. Falls are a major cause of disability and even mortality due to injury (Dhital et al. 2010; Gillespie et al. 2012; Hoops et al. 2012; Lee et al. 2012; Karlsson et al. 2013). The fear of falling may also affect quality of life, providing a significant limitation on daily activities (Department of Health 2001).

The effects of falls depend to an important extent on bone mineral density (WHO 1998b). Bone mineral density decreases to some extent physiologically with age. Proportionally, the risk of bone fractures increases (Cheng et al. 1997). Loss of bone mineral density, also known as osteoporosis, begins at around the age of 40, and mainly afflicts women, especially after the onset of menopause. Hormonal changes (particularly decline in oestrogens) are partly responsible for such bone thinning, but decrease of muscle mass is also a major cause of bone mineral loss. Research has shown that after a peak in early adulthood, muscle mass declines with age (Rantanen et al. 2003; Cruz-Jentoft et al. 2010). Both the number and size of muscle cells decrease. Because muscle mass has a direct impact upon bone mineral density, weight-bearing exercise is a standard treatment for osteoporosis and osteopenia. Bone mineral loss thus can be slowed down significantly with exercise. Neuromuscular coordination, proprioception and postural stability also contribute to the prevention of falls (Dargent-Molina et al. 1996), and these can all be manipulated with regular physical activity (Bacher et al. 2002; WHO 2002a: 28; Chubak et al. 2006).

But even when someone *already* suffers from disabling loss of bone mineral density, with consequent reduced mobility and independence, exercise can be an effective treatment (Suominen 2006). Research provides slightly different data on the amounts and regimes of exercise required for older people already affected by different musculoskeletal conditions (Moreira et al. 2014). However, a positive correlation is observed between resistance training, bone mineral density and muscular strength. Some research shows that after only six months' strength training, muscular strength increases by 9 per cent (lower body) and 18 per cent (upper body) in people aged 70–79 (WHO 2002a: 5; Gianoudis et al. 2012; Ribeiro and Neri 2012).

Developing muscular strength is not just an effective prevention and treatment for osteoporosis: walking, climbing stairs and overall mobility rely on muscular strength (Studenski et al. 2011), particularly leg strength, and when this is poor, a person clearly becomes more dependent and increasingly frail. It could be argued that the quality of life of the long-lived person is thus to an important extent dependent on one single factor: *muscular strength*, particularly leg muscular strength, and this is highly controllable (HM Government 2014).

Cardiovascular diseases

It might be believed that living longer exposes us to cardiovascular diseases because the heart, like any other muscle, loses strength as we age. In reality, other factors relating to lifestyle represent a more significant risk than chronological age. It is common knowledge that smoking, a diet rich in saturated fats and salts, and a sedentary lifestyle are major risk factors for cardiovascular diseases. Recent research also notes a correlation between loneliness, social isolation and poor cardiovascular health (Courtin and Knapp 2015).

Epidemiological studies show that perhaps one of the most important factors for the prevention of premature death from cardiovascular diseases is physical activity, even in people with established heart diseases. Physical activity reduces the risk of death from cardiac disease by 20–25 per cent among people with established heart diseases (Shiroma and Lee 2010; Longobardi et al. 2012: S99). Positive changes are manifested in cardiovascular efficiency, blood lipids, blood pressure and thrombotic tendency (WHO 1998a: 6). Physical activity has a direct effect on the heart, as it may increase oxygen supply and improve myocardial contraction and electrical stability. Moreover, physical activity increases the diameter of the coronary arteries and this also contributes to reduction of blood pressure at rest (both systolic and diastolic). Blood lipid profile is also positively affected.

What is more, regular exercise prevents the occurrence of cardiovascular diseases *in those predisposed to them*. This is one of the clear cases in which genetics and biology can be, to an important extent, controlled through lifestyle. A person initially 'at risk' because of her family history can turn out to be a 'fitter than average' person. In short, diseases of the cardiovascular system, which, it is worth remembering, are the leading cause of death in many countries, are a result of many factors, and are not the inevitable consequence of longevity.

Reduced mobility

Mobility clearly has a direct influence on a person's functional capacity and quality of life. Loss of mobility means dependency, and dependency means costs. The first age-related changes that affect mobility are anthropometric changes. They are related to both stature and the joints' range of motion. People between 65 and 74 years old are approximately 3 per cent shorter than people between 18 and 24 years old. This is likely to result from the shortening of intervertebral disc spaces and resulting kyphosis. This shortening begins at the age of 30 for most people and increases after the age of 40.

The range of motion of the joints also declines physiologically. In addition, decrements in the sensory-motor system produce a decline in postural balance. Poor balance, posture and physical coordination may also increase the risk of injuries or falls due to false movements (Salzman 2010; Farley et al. 2011: 163).

Deterioration of the musculoskeletal system is not simply or mainly a function of age, but primarily of a sedentary lifestyle. Simply *moving* and working out in different areas (balance, agility, coordination and skeletal flexibility) reduces the spontaneous loss in these areas.

Metabolic diseases

Older people generally tend to 'put on weight'. It is thought that this is in part due to the decline in metabolic rate, that is, the ability of our body to burn calories at rest. Changes in metabolic rate depend on various factors, and age is not their primary cause. Metabolic rates depend to a very important degree on muscle mass. The more muscle mass we have, the faster our metabolism. This is why weight-loss training now no longer incorporates just aerobic and cardiovascular exercise, but also strength training. As we age, we experience a physiological loss of muscle mass. However, this physiological loss is exacerbated usually by the person becoming less active and can be counteracted by exercise.

Maintaining good metabolic fitness is important in order to prevent obesity, which is often associated with greater risk of coronary heart diseases and diabetes (Type 2). Energy metabolism can be improved significantly with exercise, and so again the reduction of metabolic rates can be delayed, prevented or contained.

Among the metabolic changes that may affect us, those relating to glucose metabolism are particularly worrisome. Poor glucose tolerance may lead to diabetes (Type 2, which generally occurs after the age of 40), which is characterised by variable degrees of insulin resistance and relative insulin deficiency. In its later stages, diabetes is associated with a number of serious disorders that have a great impact upon a person's quality of life (e.g. blindness, kidney diseases, heart diseases, stroke and peripheral vascular diseases severe enough to result in the amputation of a leg or foot). Again age is not the sole or even the main determinant of these metabolic changes. Genetic predisposition, but also obesity and physical inactivity, increase these risks. Whereas not much can be done to change our genetic predisposition, being genetically predisposed does not necessarily mean developing the disease: lifestyle can significantly alter the probability that people genetically predisposed to metabolic diseases will actually become affected by them. In particular, exercise improves the glucose metabolism, and so not only can prevent metabolic diseases, but can also assist in the treatment of those who have developed them (International Diabetes Federation 2013).

Cognitive functioning

Old age is often associated with decline in cognitive function, but this association must be understood properly. Research suggests that 'capacity to tackle complex tasks that require dividing or switching attention' (WHO 2015a: 55) may decrease as we age; also our ability to 'learn and master tasks that involve active manipulation, reorganization, integration or

anticipation of various memory items' (WHO 2015a: 55) may decrease with age. However, the capacity to maintain concentration, avoid distraction, 'memory for factual information, knowledge of words and concepts, memory related to the personal past, and procedural memory . . . language features, such as comprehension, reading and vocabulary' (WHO 2015a: 55) do not deteriorate with age and remain stable throughout life.

Mental health: affective disorders and dementia

Affective disorders, particularly depression, are major afflictions for older people, but often, like dementia, go unnoticed at least during the early stages, as they are taken as an inevitable feature of ageing (Department of Health, UK 2001: 19). Again, however, the association between living longer and suffering from affective disorders needs to be properly understood. First, what is sometimes perceived as a feature of old age is in fact a disease that has multiple causes: these have often little to do with how long someone has lived (though they may be related to exposure to adverse life events, such as multiple losses of significant others) (Seitz et al. 2010). Second, the prevalence of depressive and anxiety disorders is in fact slightly lower among older adults than among younger adults (with the exception of older adults living in care homes) (WHO 2015a: 58). Third, whereas it is notoriously difficult to treat multifactorial diseases, it is possible to prevent them and ameliorate the conditions of those who suffer from them, regardless of their age.

With regard to dementia, the WHO predicts that the current number of sufferers (47 million people) is going to triple by 2050 (WHO 2015a: 59). In the UK, projections are for an increase in the overall number of cases from 822,000 in 2016 to 1.7 million by 2051 (GOS 2016: 77). But dementia is not simply a result of longevity. In fact, research shows that certain types of dementia may be prevented by reducing the risk factors for cardiovascular diseases.[1]

Once again, it appears that exercise has a major role in preventing and reducing the impact of mental illness among the long-lived. Earlier studies in gerontology suggest that regular physical activity helps to maintain and improve functional ability, health and mental well-being in the older person (Ruuskanen and Ruopilla 1995). More recent studies seem to confirm these findings (Weuve et al. 2004; Ikeda et al. 2012; Steinmo et al. 2014). It has been found that walking can help to prevent vascular-related dementia (HM Government 2014: 4, Annex A). It has also been noticed that people who perform regular aerobic exercise tend to suffer from depression less than inactive people, although it has been impossible to establish what the causal connection between the two is. Some studies suggest that exercise may make older people able to cope independently, and may thereby enhance self-esteem and confidence, which, in turn, may help to prevent or reduce depression (O'Connor et al. 1993). Physical exercise is also considered as a treatment for anxiety. It is associated with improved general satisfaction

Box 2.1 Physical (in)activity and spending

Physical inactivity costs the national health services nearly as much as smoking. Inactivity in the UK costs around £20bn per year (HM Government, 2014: 5).

Physically active people incur fewer direct medical costs than inactive people (Pratt et al. 2000; Wang et al. 2004; Hagberg and Lindholm 2006; Franklin 2008).

Physically active people have fewer periods in hospital, go to the doctor less frequently, and use less medication than inactive people.

People in work who are physically active have lower rates of sickness absence, fewer retirements on health grounds and are more productive (HM Government 2014: 12).

Absenteeism related to physical activity costs the economy 5.6bn per year (Cabinet Office for Urban Transport 2009, cited in HM Government 2014: 14).

Physical activity has indirect financial benefits: in London town centres in 2011 walkers spent £147 more per month than those travelling by car, thus contributing to the economy (Department for Transport 2012).

An increase in 1 per cent in physical activity could save 1.2bn over five years (HM Government 2014: 5).

Across a town of 150,000 people, if everyone walked an extra 10 minutes a day, 31 lives and 30 million£ per year would be saved (HM Government 2014: 4, Annex A).

People who are physically active also have 30 per cent–50 per cent reduced risk of getting colon cancer (Department of Health 2004), and approximately 20 per cent reduced risk of breast cancer (US Department of Health and Human Services 2008).

Public policy in England and in other countries now reflects and incorporates these findings.[2]

and well-being (WHO 1998b: 9.) Moreover, physical activity is associated with better social adjustment and cognitive functioning. It may enrich the social life of the elderly, as it may be a way of meeting other people. Social participation greatly affects the quality of our life, and isolation is associated with higher mortality among older people (Sugisawa et al. 1994).

Intergenerational relationships

As mentioned in the Introduction, there are various steps that can be taken to avoid certain negative outcomes. One element conducive to healthy ageing

that has been identified in the literature is intergenerational dialogue and solidarity. Phillipson argues that part of the worry relating to longevity is the liberal assumption, embedded in many Western democracies, that the state has (through its welfare system) the main responsibility for vulnerable members of society. Increases in longevity and the related modification in population structure challenge this assumption. Phillipson argues that forms of solidarity need to accompany state responsibilities. He writes:

> [W]e need to think about new forms of solidarity both to replace existing institutions and to indicate the basis for alternative forms of social action. Four illustrations [can] be made to develop this point: first, identifying forms of cooperation that bring together different generational interests; second, reconnecting to the original vision of the welfare state; third, adopting a human rights perspective in old age; and fourth, restoring meaning and dignity to the end of life. (2015: 90–1)

Phillipson's suggestion echoes an older recommendation made by the WHO. In *Active Ageing* (2002a) the WHO recognised that negative attitudes towards older people result partly from a lack of interaction among age groups. In some societies, intergenerational dialogue is simply a part of life. In many Asian countries, for example, extended families live in multigenerational households. In many European countries, however, where the nuclear (and the blended) family has replaced the extended family, intergenerational dialogue has to be a conscious choice (WHO 2002a: 20).

Intergenerational cooperation would allow the older person to have some interests in common with younger generations, to exercise his or her skills (memory, learning and cognitive abilities) and to continue to contribute to the changing labour market. Moreover, intergenerational dialogue promotes the transmission of values between different age groups and a more positive and realistic attitude of the younger towards the older.

The WHO advised a number of key action points: schools and communities should provide intergenerational activities such as training in new technologies for older people and opportunities for lifelong learning (2002a: 52); intergenerational solidarity could be enhanced by 'supporting traditional societies and community groups run by older people, voluntarism, neighbourhood helping, peer monitoring and visiting' (WHO 2002a: 28).

Phillipson, similarly, offers some examples of existing intergenerational cooperation and provides ideas for further development of intergenerational solidarity:

> [An] important area for informal education has been the development of 'intergenerational learning' – that is, educational programs that link older with younger learners. Newman and Hatton-Yeo (2008) cite the example of the NUGRAN program at the University of Valencia, which creates learning experiences that cross the generations, involving older and younger adults together, with the aim of promoting greater contact, trust, and more positive

> attitudes between them. The program began with 71 students in 1999 and had expanded to 1,000 by 2007. Achenbaum (2005: 61) provides similar examples from the United States, citing in particular the partnership between the University of North Carolina at Asheville and the North Carolina Center for Creative Retirement: 'Participants take classes that they design, conduct inter-generational programs to develop leadership skills, and analyze problems in the community and at the state level.' (2015: 90–1)

There are also, Phillipson points out, common interests:

> Pillemer et al. (2010) argue that older people represent an important source for creating solutions to environmental problems through volunteering and civic engagement, drawing upon their own knowledge and experience . . . Steinig and Butts (2010), discussing the U.S. experience, highlight the fact that intergenerational strategies can have a positive impact on the environment through shared sites and housing developments that bring generations together. (2015: 92)

There are many other key actions that can and perhaps ought to be implemented, in order to ensure the sustainability of a long-lived world. In this short chapter it is not possible to cover them in detail. Gratton and Scott have provided an accurate analysis of the various comprehensive changes that need to be taken in order to ensure that longevity is not a curse, but an exciting opportunity. I will list some of the key action points here and refer to their book for an in-depth analysis (Gratton and Scott 2016).

- Pension system/long-term investment: people will have to work for longer and retirement age will need to increase. Work flexibility and a different balance of work/leisure time will need to be implemented to prevent burnout and exhaustion.
- A longer life cannot be structured in the traditional three stages (education/work/retirement); a longer life will be multi-stage; education and employment will need to become more flexible; long-lived people will need to requalify over time.
- There will be a greater number of career transitions. Psychology and sociology have the task of understanding how people can make smoother career transitions.
- Architecture/infrastructure need to accommodate the growing proportion of older people: housing and city planning will need to accommodate the needs of older people.

Happily ever after?

Longevity is one of the greatest triumphs of humankind. The fact that we will all live longer raises many worries, however. Old age worries not only

individuals, but also our collective psychology: people worry about what is going to happen to our planet, how our societies are going to function, given that the over-sixties are becoming the largest section of society.

However, not only is the pressure that the long-lived are perceived to present exaggerated, it can also be further reduced. There are of course other strategies by which being old could be made more desirable, but I have proposed that we should start with simple and realistic steps: dismantling some myths relating to longevity, understanding how diseases often associated with longevity may be effectively prevented (Bostrom 2005) and promoting intergenerational dialogue and solidarity.

This is not to say, of course, that individuals should bear the responsibility for their own health as they age. It is instead to say that policies that involve relatively minor costs could bring high benefits for all (older and younger). Healthy longevity is the result of a concerted effort that must happen at various levels, and stressing individual ability to control health is only one of them. Whether or not we, say, keep walking as we grow older depends not just on whether we have sufficient mobility, or whether we are willing to do so, but also on whether there is a set of infrastructures that allow us to feel safe in walking. The Brasilia Declaration on Ageing recommends that '[a]ll actions must . . . take into account the bio-physical, social, psychological, economic, and environmental determinants of health. Policies across sectors [of local government and its employees] must be coordinated and harmonized' (WHO 1996).

How we age, partly depends on luck of course; but it also depends on behavioural and environmental factors: luck aside, these can be controlled, but only through a coordinated effort (HM Government 2014: 5). Infrastructures and architectonic designs must reflect the findings relating to longevity. Safe areas for walking, well-lit streets, adequate pavements (together with pedestrian traffic lights that have sufficient duration for those with reduced mobility); support for community activities that encourage physical activity; provision of recreational services that offer elderly people exercise programmes that help them to maintain their mobility; the inclusion of information and education about longevity in the training programmes of health carers, social carers, recreational workers, city planners and architects; provision of pavements and cycle tracks close to residential areas to encourage walking or cycling as a part of daily activity; easy access to information about healthy longevity – these are just a few examples of cost-effective policies aimed at promoting *good longevity* (WHO 2015b).

Population ageing has not only raised mixed reaction and worries; it has also raised awareness of the need to protect older members of society from abuse and discrimination. One of the first documents on the rights of the older person was the Brasilia Declaration on Ageing (WHO 1996). One of the most recent was the Declaration of Rights for Older People in Wales (2014), and the United Nations is calling for a legally binding convention on the rights of older people (Office of the High Commissioner for Human

Rights 2014). Virtually all declarations and conventions on human rights contain statements about the fundamental human right of the elderly not to be discriminated against; for example, the Convention for the Protection of Human Rights and Fundamental Freedoms as amended by Protocol n. 11, 4 November 1950, art. 14, Prohibition of discrimination; or the European Social Charter (Revised) (3 May 1996), Part V, art. E.[3] The Charter of Fundamental Rights of the European Union (2000) prohibits:

> Any discrimination based on any ground such as sex, race, colour, ethnic or social origin, genetic features, language, religion or belief, political or any other opinion, membership of a national minority, property, birth, disability, *age* or sexual orientation. (art. 21, non-discrimination – my emphasis)

Universal ethical principles, however, remain abstract and empty concepts, mere unfulfilled ideals, unless policy directed at improving people's lives is implemented. When a policy involves relatively minor costs and high benefits for all (older and younger), it is clearly morally irresponsible not to endorse it.

The growing proportion of elderly people is a sign of the achievements of humankind in extending life and improving life conditions. This growth means that all of us get a better chance of living longer. This is to be celebrated as one of our greatest accomplishments, and the contribution that older people offer to society is to be appreciated, promoted and defended.

Notes

1 Further information on dementia can be found in other WHO documents that focus specifically on this topic at www.who.int/topics/dementia/en.

2 For example, in England the Department of Health has published a report (2011). See also HM Government (2014: 10). The American College of Sports Medicine (2010) also has various guidelines on healthy ageing, and recommends public policy to ensure promotion of physical activity as a public health measure. Wales has introduced, in 2014, the Active Travel Act, an Act of Parliament that requires local authorities to continuously improve facilities and routes for pedestrians and cyclists. This act requires local authorities to publish maps of safe walking and cycling routes and enhance these over time and new road schemes to consider the needs of pedestrians and cyclists (HM Government, 2014: 13).

3 Including also Universal Declaration of Human Rights 1948, Preamble; Council of Europe Convention for the Protection of Human Rights and Dignity of the Human Being with Regard to the Application of Biology and Medicine: Convention on Human Rights and Biomedicine 1997; United Nations Convention on Elimination of All Forms of Discrimination Against Women 1981.

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