Ageing 2

The burden of disease in older people and implications for health policy and practice

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23% of the total global burden of disease is attributable to disorders in people aged 60 years and older. Although the proportion of the burden arising from older people (≥60 years) is highest in high-income regions, disability-adjusted life years (DALYs) per head are 40% higher in low-income and middle-income regions, accounted for by the increased burden per head of population arising from cardiovascular diseases, and sensory, respiratory, and infectious disorders. The leading contributors to disease burden in older people are cardiovascular diseases (30·3% of the total burden in people aged 60 years and older), malignant neoplasms (15·1%), chronic respiratory diseases (9·5%), musculoskeletal diseases (7·5%), and neurological and mental disorders (6·6%). A substantial and increased proportion of morbidity and mortality due to chronic disease occurs in older people. Primary prevention in adults aged younger than 60 years will improve health in successive cohorts of older people, but much of the potential to reduce disease burden will come from more effective primary, secondary, and tertiary prevention targeting older people. Obstacles include misplaced global health priorities, ageism, the poor preparedness of health systems to deliver age-appropriate care for chronic diseases, and the complexity of integrating care for complex multimorbidities. Although population ageing is driving the worldwide epidemic of chronic diseases, substantial untapped potential exists to modify the relation between chronological age and health. This objective is especially important for the most age-dependent disorders (ie, dementia, stroke, chronic obstructive pulmonary disease, and vision impairment), for which the burden of disease arises more from disability than from mortality, and for which long-term care costs outweigh health expenditure. The societal cost of these disorders is enormous.

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This is the second in a Series of five papers about ageing

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Introduction

The greatly increased expectancy of survival into old age is one of humanity's major achievements.[1] To the contrary, worldwide population ageing and the attendant increases in public spending on health and social care are seen as a threat to worldwide economic stability in the 21st Century.[2] Informed policy making and planning necessitates an understanding of the present and probable future distribution of morbidity and its effect on mortality, disability, and dependence. Several effects need to be considered; demographic and epidemiological transitions and secular changes in the effectiveness and coverage of disease control measures. Effects will vary between disorders and regions.

The worldwide epidemic of chronic diseases is strongly linked to population ageing. Disorders with a strong age-dependent relation will increase in prevalence in parallel with the absolute and relative numbers (relative to the total population size) of older people (≥60 years). In high-income countries, population ageing persists as fertility continues to fall and life expectancy increases slowly. For many middle-income countries mortality has decreased over much of the 20th century, and decreasing fertility is now ushering in unprecedented rapid population ageing. The doubling in the proportion of the population aged 65 years and older from 7% to 14%, accomplished in 46 years in the UK, 68 years in the USA, and 116 years in France, will be completed in just 26 years in China and 21 years in Brazil.[3] The appendix reviews the implications for China and national policy directions.

The epidemiological transition from the age of pestilence and famine to the age of degenerative and man-made diseases is near complete in most high-income countries. Low-income and middle-income countries face various gradations of a double burden of infectious and non-communicable diseases, the balance

Key messages

- 23% the global burden of disease arises in older people (nearly half the burden in high-income countries and a fifth in low-income and middle-income countries)
- Chronic non-communicable diseases account for most of the burden; leading contributors are cardiovascular diseases, cancer, chronic respiratory diseases, musculoskeletal diseases, and mental and neurological disorders
- Population ageing will be the major driver of projected increases in disease burden in older people, most evident in low-income and middle-income countries and for strongly age-dependent disorders (dementia, stroke, chronic obstructive pulmonary disease, and diabetes). These are also the disorders for which chronic disability makes a substantial contribution to burden
- Primary and secondary prevention for cardiometabolic disorders is probably as effective in older people as it is in younger people, and the benefit is increased in view raised levels of absolute risk of adverse outcomes. Nevertheless, access and coverage is especially poor in older people
- Effective intervention in older people is complicated by ageism, complex multimorbidity, and no access to age-appropriate care, and is exacerbated by user fees, inadequate income security and social protection. Assessment and treatment needs to be holistic, coordinated and person-centred. Home-based outreach, and multidimensional assessment of frailties that might be treated or mitigated might help to reduce individual and societal effects on disability and dependence

Search strategy and selection criteria

We analysed Disability Adjusted Life Years (DALYs) data for people aged 60 years and older from the Global Burden of Disease (GBD) estimates generated by the Institute of Health Metrics and Evaluation (IHME GBD—1990 and 2010),[4] and WHO (WHO GBD—2004 update with projections to 2030)[5] Although priority is given throughout to the present IHME estimates, this approach enabled us to critically examine the effects of the previous WHO[6] and IHME[7] disability weights on the relative burden of different disease groups and to report future projections (WHO GBD) and trends from 1990 to 2010 (IHME GBD). For consistency, we used unweighted DALYs with no future discount,[4] other than for calculation of increase in WHO GBD DALYs between 2004 and 2030, where, in absence of unweighted estimates for 2030, age-weighted and discounted DALYs were used. Further information in terms of prevalence, incidence, and effect of key chronic disorders was obtained from a narrative review of the reported studies for each major health disorders. We searched PubMed using Mesh terms (("Aged"[Mesh] OR "Aged, 80 and over"[Mesh]) AND "Arthritis"[Mesh]) AND ("Prevalence"[Mesh] OR "epidemiology" [Subheading]). We focused on nationally representative surveys and comprehensive reviews, supplemented with evidence from large population-based multinational surveys of older populations.[8,10] We modelled the effects of age, sex, and education on chronic disease outcomes with individual participant data with harmonised exposures and outcomes from 10/66 Dementia Research Group[8] and WHO SAGE[11] population-based surveys of people aged 65 years and older done in 12 countries in Latin America, Africa, and Asia (appendix). We sought evidence for cost-effective interventions from cost-effectiveness analyses for sub-Saharan Africa and southeast Asia regions with WHO-CHOICE methods[12] and the 2nd edition of Disease Control Priorities in Developing Countries.[13]

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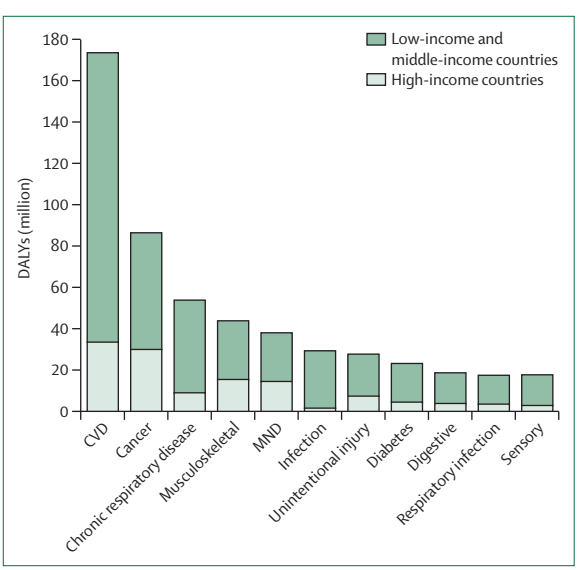

Figure 1: **Leading contributors to burden of disease in people aged 60 years and older in 2010—DALYs (million) by cause and World Bank income**
DALYs=disability-adjusted life years. CVD=cardiovascular and circulatory diseases. MND=mental and neurological disorders, combining the IHME GBD mental and behavioural disorders and neurological disorders groups.

shifting inexorably towards non-communicable diseases. A globalisation of risk behaviours; including diets rich in saturated fat and increase of tobacco use and under-activity, with consequent obesity; partly causes the rapid increase in burden of chronic diseases in these regions. After the transition, in high-income countries, cardiovascular risk factors and diseases are typically associated with economic disadvantage and low levels of education, but the trend is often in the opposite direction in low-income and middle-income countries.

In high-income countries, mortality from cardiovascular disease has been decreasing in all age groups. The average age of first onset and death from cardiovascular disease has been increasing and shifting the burden into older age. Decreasing incidence plays a part, but case fatality rates have also fallen with improved acute hospital management. Since prevalence is a product of incidence and duration, long survival for these and other chronic diseases has a profound effect on population burden, particularly on years lived with disability and needs for care.

In this Review, we trace these changing patterns examining present and future burden of major chronic diseases of particular relevance to older people (cardiovascular diseases [stroke and ischaemic heart disease], cancer, diabetes, chronic respiratory diseases, visual impairment, dementia, and musculoskeletal disorders) across world regions by income level and their underlying risk factors and evidence-based treatments. We complement this disorder-based approach by reviewing three cross-cutting themes; frailty, multimorbidity, and ageism in the provision of service; that distinctively characterise the interaction of ageing and health and pose challenges and opportunities to strengthen health systems to meet the needs of older people.

Overview of burden of disease in older people

According to the Global Burden of Disease (GBD) estimates for 2010, 23·1% of the total disease burden (574 million of the 2490 million DALYs) is attributable to disorders in people aged 60 years and older, 49·2% of the burden in high-income regions, and 19·9% in low-income and middle-income regions.[4] For the disorder clusters (figure 1, table), the leading contributors to disease burden in older people are cardiovascular diseases, malignant neoplasms, chronic respiratory diseases, musculoskeletal diseases, mental and neurological disorders, infectious and parasitic diseases, unintentional injuries, diabetes mellitus, digestive diseases, respiratory infections, and sense organ diseases (table). The rank order does not vary greatly by region income, but infectious and parasitic diseases make a more prominent contribution in low-income and middle-income regions, and mental and neurological disorders and musculoskeletal diseases make a more prominent contribution in high-income regions. The disease burden per person in older people is higher in low-income and middle-income regions (827 DALYs per 1000) than in high-income regions (590 DALYs per 1000) which is accounted for by the increased burden per head from cardiovascular disease, chronic respiratory, and infectious disorders in low-income and middle-income regions (figure 2).

	1990 IHME GBD	2010 IHME GBD	Change 1990–2010 IHME GBD (%)	2004 WHO GBD (unweighted, no discount)	Change 2004 to 2030 (weighted and discounted; %)
General					
Population aged ≥60 years (millions)	487·5	754·9	..	658·7	..
All causes	434·8 (100%)	574·4 (100%)	+32·1%	450·9 (100%)	+55·2%
DALYs per 1000 population	891·9	760·9	..	684·5	..
GBD categories					
Communicable, maternal, perinatal, and nutritional conditions	45·2 (10·4%)	53·3 (9·3%)	+17·9%	38·6 (8·6%)	–18·7%
Non-communicable diseases	368·3 (84·7%)	488·6 (85·1%)	+32·7%	395·5 (87·7%)	+61·3%
Injuries	21·3 (4·9%)	32·6 (5·7%)	+53·1%	16·8 (3·7%)	+78·0%
Burdensome chronic non-communicable disease categories					
Cardiovascular diseases	137·3 (31·6%)	173·9 (30·3%)	+26·7%	157·4 (34·9%)	+40·6%
Cancer	64·4 (14·8%)	87·0 (15·1%)	+35·1%	65·3 (14·5%)	+69·2%
Chronic respiratory diseases	54·9 (12·6%)	54·3 (9·5%)	–1·1%	41·0 (9·1%)	+84·3%
Digestive diseases	15·8 (3·6%)	19·4 (3·4%)	+22·8%	15·2 (3·4%)	+15·8%
Mental and behavioural, and neurological disorders	22·2 (5·1%)	38·0 (6·6%)	+71·2%	31·0 (6·9%)	+79·5%
Sensory impairment	12·3 (2·8%)	18·0 (3·1%)	+46·3%	43·9 (9·7%)	+82·0%
Musculoskeletal	27·9 (6·4%)	43·3 (7·5%)	+55·2%	12·1 (2·7%)	+70·3%
Genitourinary diseases	9·4 (2·2%)	16·4 (2·9%)	+74·5%	7·5 (1·7%)	+61·1%
Burdensome chronic non-communicable diseases					
Ischaemic heart disease	60·7 (14·0%)	77·7 (13·5%)	+28·0%	67·6 (15·0%)	+34·7%
Cerebrovascular disease	54·5 (12·5%)	66·4 (11·6%)	+21·8%	55·4 (12·3%)	+44·4%
Diabetes mellitus	12·6 (2·9%)	22·6 (3·9%)	+79·4%	13·9 (3·1%)	+95·7%
Chronic obstructive pulmonary disease	44·7 (10·3%)	43·3 (7·5%)	–3·1%	33·1 (7·3%)	+88·7%
Dementia	4·7 (1·1%)	10·0 (1·7%)	+112·8%	18·8 (4·2%)	+82·6%
Vision impairment	7·0 (1·6%)	10·4 (1·8%)	+48·6%	30·9 (6·8%)	+86·3%
Hearing impairment	5·3 (1·2%)	7·5 (1·3%)	+41·5%	13·0 (2·9%)	+70·6%

IHME=the Institute of Health Metrics and Evaluation. GBD=global burden of disease.

Table: **Numbers and proportion (%) of DALYs attributable to particular causes, for people aged 60 years and older in 1990 and 2010 (IHME GBD) and 2004 with projections to 2030 (WHO GBD)**

For older people, the 15 most burdensome disorders are ischaemic heart disease (77·7 million DALYs); stroke (66·4 million); chronic obstructive pulmonary disease (COPD, 43·3 million); diabetes (22·6 million); low back pain (19·1 million); cancer of the trachea, bronchus; or lung (18·6 million); falls (12·4 million); visual impairment (10·4 million); dementia (10·0 million); tuberculosis (9·2 million); hypertensive heart disease (9·5 million); stomach cancer (8·6 million); hearing loss (7·5 million); osteoarthritis (7·5 million); and major depressive disorder (7·5 million).

Social and demographic determinants

The appendix summarises the results of a meta-analysis modelling the independent effects of age, sex, and education on the prevalence of obesity, hypertension, diabetes, ischaemic heart disease, stroke, depression, and dementia from 10/66 Dementia Research Group[5] and WHO-SAGE[6] population surveys in 12 low-income and middle-income countries in Africa, Asia, and Latin America. Stroke was more common in men than in women, but the prevalence of other disorders was consistently higher in women. Age dependency was most evident for dementia (prevalence ratio per 5-year increment in age 1·61, 95% CI 1·57–1·66) and stroke (1·15, 1·11–1·19), and, to a lesser extent, ischaemic heart disease (1·06, 1·03–1·09). The prevalence of diabetes and obesity decreased slightly with increasing age. Prevalence of depression and dementia was higher in those with lower levels of education in all settings. For cardiometabolic disorders (obesity, hypertension, diabetes, stroke, and ischaemic heart disease), the association with educational level depended on development status. For urban and more developed settings, prevalence was higher in those with lower education levels, whereas for less advanced settings, the association was in the opposite direction.

Risk exposures

The profile of lifestyle-related risk factors is much the same across the most burdensome disorders for older people. Dyslipidaemia, hypertension, diabetes, smoking, and obesity are the major modifiable risk factors for

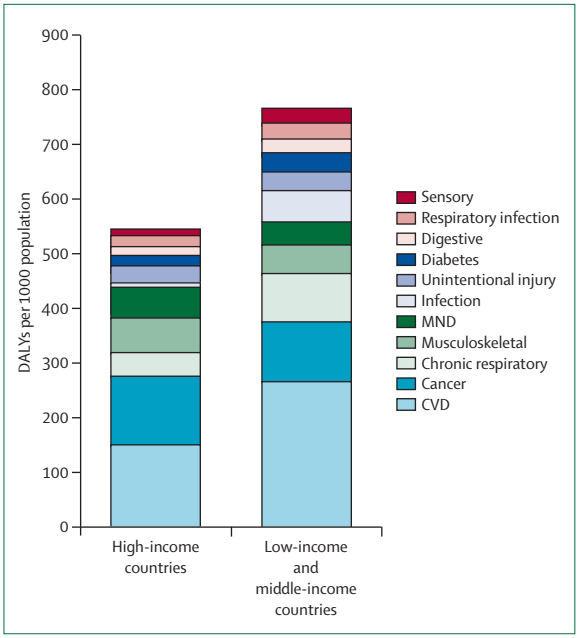

Figure 2: **Leading contributors to burden of disease in people aged 60 years and older—DALYs (per 1000 population) in people aged 60 years and older by cause and income region.**
DALYs=disability-adjusted life years. CVD=cardiovascular and circulatory diseases. MND=mental and neurological disorders, combining the IHME GBD mental and behavioural disorders and neurological disorders groups.

cardiovascular diseases.[7] Smoking is also the main modifiable risk factor for cataract and age-related macular degeneration,[8] COPD,[9] and lung cancer[10] in old age. A review[11] of risk factors for Alzheimer's disease identified consistent evidence from cohort studies to accord with a causal role for smoking, physical inactivity, midlife hypertension, obesity, and diabetes.

The prevalence of most of these risk factors rises with increasing age. In the US National Health and Nutrition Examination Survey (NHANES) 2003–08, this pattern was apparent for physical inactivity, total cholesterol, fasting blood glucose, and blood pressure.[12] Only smoking was less common in older adults than in adults younger than 60 years. The age gradient for hypertension is especially steep. For NHANES 1999–2004, 60% of people aged 60–69 years were hypertensive, which rose to 72% for people aged 70–79 years and 77% for people aged 80 years and older.[13] In low-income and middle-income countries, prevalence of hypertension also increased steadily with age, with half or more of people aged 60 years and older affected.[14–18] Risk exposures are probably higher in urban than rural settings in low-income and middle-income countries, as shown in the 10/66 DRG surveys for hypertension[14] (urban sites range 52·6–79·8%, rural sites range 42·6–56·9%), which accords with a pattern previously reported in Bangladesh and India.[15]

Cardiovascular risk factors operate into old age, although relative risks might be attenuated. Thus in the INTERHEART[7] and INTERSTROKE[16] case-control studies hypertension was an independent risk factor for acute myocardial infarction and stroke in older people in all countries. In the USA, hypertension in older people is also an independent risk factor for mortality[17] and is inversely associated with healthy ageing.[18] The Prospective Studies Collaboration meta-analyses[19] support associations of lower than usual systolic blood pressure with reduced stroke (relative risk 0·67, 95% CI 0·63–0·71) and ischaemic heart disease mortality (0·67, 0·64–0·70), and of decreased total cholesterol (RR per 1 mmol/L reduction 0·85, 0·82–0·89) with ischaemic heart disease mortality.[20] Although these relative risks were attenuated compared with younger age groups, absolute risk differences are more enhanced in view of increased mortality due to cardiovascular disease in older people. In European cohort studies, continued smoking, poor quality diet,[21] and physical inactivity[21,22] were independently associated with increased mortality into the eighth decade of life. However, in India the strength of the association of smoking with mortality attenuates sharply into older age,[23,24] and undernutrition[25] rather than obesity[26] is more consistently associated with increased mortality.

The benefits of risk factor modification in older people are most clear for control of hypertension and hypercholesterolaemia. In a meta-analysis of 15 trials of diuretics or β blockers in people aged 60 years or older, event rates per 1000 people during a period of 5 years were reduced by 18 (95% CI 4–28) for all deaths, by 19 (9–31) for cardiovascular deaths, and by 51 (31–73) for cardiovascular morbidity and mortality combined.[27] Benefits were apparent for isolated systolic and diastolic hypertension.[27] Numbers needed to treat to avoid an event are much smaller than at younger ages.[28] In a meta-analysis of results of cholesterol-lowering treatment from 14 randomised trials of statins, the benefits were apparent for patients aged 75 years and older, with reduction of the risk of major vascular and major coronary events.[29]

In the US NHANES surveys 1999–2004, control of hypertension in patients treated was especially suboptimum in older age groups, with only 47% controlled in patients aged 60–79 years and 36% in patients aged 80 years and older.[30] The situation is likely to be much worse in low-income and middle-income countries.[15,31] In the 10/66 DRG surveys, in most Latin American centres and urban China, 40–50% of people reporting a diagnosis of hypertension were controlled; however, control was especially poor in rural China (5%), urban India (30%), rural India (31%), and Cuba (32%); control of hypertension, rather than compositional factors (age, sex, education, and obesity), explained most of the variation between sites in systolic blood pressure levels.[14]

Cardiovascular diseases

The profile of cardiovascular disease develops gradually with the epidemiological transition.[32] As mortality decreases, nutrition improves and infections are

controlled, and hypertension, ischaemic heart disease, and stroke become more prevalent, with ischaemic heart disease contributing most to mortality. As high-income countries advance into the so-called age of delayed degenerative diseases, age-adjusted mortality due to cardiovascular disease decreases with effective primary and secondary prevention and better acute hospital management. Cardiovascular disease, particularly ischaemic heart disease, is still the leading cause of death. However, the effects of congestive heart failure and atrial fibrillation, strongly associated with older age and ischaemic heart disease, increase greatly with population ageing and improved survival from myocardial infarction.[33,34] A growing urgency exists to tackle cardiovascular diseases in low-income and middle-income countries through effective prevention and treatment, guided and monitored by robust estimates of disease prevalence and burden. Although much of the evidence refers to young and middle-aged adults,[35–37] older people account for most cardiovascular disease morbidity and mortality in these regions.

Ischaemic heart disease accounted for 77·7 million DALYs in older people in 2010, 78% of the burden arising in low-income and middle-income regions.[38] DALY burden in older people was forecast to increase by 35% from 2004 to 2030. Lifetime prevalence of ischaemic heart disease rises largely with age; population data from US NHANES 1988–94 show a 2–4-times increase in prevalence from the age group of 40–64 years to that of 65–74 years: from 4·5% to 6·7% for self-reported angina pectoris, from 3·8% to 11·0% for self-reported myocardial infarction, and from 1·3% to 5·5% for electrocardiography confirmed myocardial infarction.[39] Between 1980 and 2000, age-standardised ischaemic heart disease mortality rates almost halved in the USA, with nearly three-quarters of the deaths prevented or postponed being in people aged 65 years and older.[40] This reduction was evenly attributed to improvements in medical care and reduced exposure to risk factors, despite increases in obesity and diabetes. Nevertheless, similar lifetime prevalence of myocardial infarction across successive NHANES cohorts suggests that a reduction in incidence of the disorder was offset by increased survival.[39]

In low-income and middle-income countries, ischaemic heart disease episodes seem to occur at younger ages;[41] 8% of deaths from ischaemic heart disease in high-income countires and 21% in low-income and middle-income countries were in people younger than 60 years of age. The trend in many low-income and middle-income countries is towards a rise of morbidity and mortality. In Beijing, China, age-adjusted mortality due to ischaemic heart disease increased by 50% in men and 27% in women over a similar period to that of decreasing mortality due to ischaemic heart disease in the USA. This increase was attributable to substantial rises in serum cholesterol, diabetes prevalence, and obesity and only partly offset by advances in medical care.[42] For men, the rise in mortality due to ischaemic heart disease was much greater at younger ages than at older ages; nevertheless, 40% of the additional deaths in men and 87% in women occurred in people aged 65–74 years.[42] In India, prevalence of ischaemic heart disease rose from 2% to 5% in rural settings and from 7% to 11% in urban settings in the last three decades of the past century.[43] Although mortality due to ischaemic heart disease in Russia and some parts of eastern Europe has increased and is still among the highest in the world, mortality in the regions that have undergone rapid economic and social transformation has fallen to a similar extent as in developed democracies.[32]

Effective ischaemic heart disease interventions target primary prevention, treatment for acute myocardial infarction, secondary prevention after myocardial infarction, and congestive heart failure. These interventions mainly include drug therapy, which, although not costly, might not always be available.[44] Most interventions included in a WHO-CHOICE[45] modelling exercise for the African and southeast Asian regions were highly cost effective (<Int$2000 per DALY averted).[44] Tobacco control is probably the most cost-effective prevention strategy, alongside combination drug therapy (statin, diuretic, β blocker, and aspirin) for individuals with an absolute risk of having a cardiovascular event in the next 10 years greater than 25%.[44] This group includes a high proportion of older people. For acute myocardial infarction, the benefits of treatment in hospital with aspirin alone are doubled when combined with streptokinase and tripled with percutaneous transluminal coronary angioplasty.[44] Rapid access to facilities that do these procedures is not yet feasible in most low-income and middle-income countries. Secondary prevention is most effective through a combination of aspirin, β blocker, statin, and angiotensin-converting-enzyme (ACE) inhibitor. Treatment of chronic heart failure with loop diuretics is highly cost-effective and might be usefully supplemented with β blocker and ACE inhibitors,[44] and, possibly, digoxin.[46]

Stroke accounted for 66·4 million DALYs in older people in 2010, 86% of the burden arising in low-income and middle-income regions. Burden in older people was predicted to increase by 44% from 2004 to 2030 (table). Stroke contributed 5·9 million deaths in 2010, 5·0 million (85%) occurring in people aged 60 years and older. In 2005, 62 million were estimated to be survivors of stroke worldwide.[47] Many survivors are likely to be disabled;[48,49] in low-income and middle-income countries, stroke was the second leading contributor (after dementia) to disability[50] and dependence in older people.[51]

In high-income-country studies,[52] age-standardised prevalence of stroke for people aged 65 years or older ranged from 4·6% to 7·3%. US NHANES 1999–2006 reported a prevalence of 6–8% for people aged 65–74 years and about 12% for those aged 75 years and older.[53] In the 10/66 DRG surveys in seven low-income and middle-income countries,[49] prevalence was similar to that in the US NHANES survey in urban sites in Latin America and

China (6·2–8·4%), but much lower in rural Peru, rural China, and urban and rural India. Ascertainment based on self-report will underestimate prevalence when stroke awareness is low, and in such settings, post-stroke mortality might be raised, perhaps accounting for low prevalence. More detailed ascertainment protocols yielded prevalences of 6·9% (65 years and older) in a rural district of Beijing,[54] and of 3·4% (60 years and older) in Kolkata.[55]

A review[52] of population-based studies of stroke incidence and case fatality in the late 20th century reported little variation in age-standardised incidence (4·2–6·5 per 1000 person years) in those done in Europe, North America, and Australasia, but higher rates in Japan, Russia, and the Ukraine. Stroke incidence was strongly age-dependent, doubling with every 10-year increment in age. The case-fatality proportion (23% within 1 month) also increased with age. Between 1970 and 2008, age-adjusted stroke incidence fell by 42% in high-income countries (–1·0% per year), but more than doubled in low-income and middle-income countries (+5·6% per year), and quadrupled in people aged 75 years or older. Since 2000, stroke incidence in low-income and middle-income countries exceeded that of high-income countries. A non-significant trend towards decreasing case fatality in all world regions was reported,[56] from 35·9% in the 1970s to 19·8% in the 2000s (–1·1% per year) in high-income countries, and from 35·2% in the 1980s to 26·6% in the 2000s (–0·6% per year) in low-income and middle-income countries. A review[57] of population-based studies reported clear inverse associations between gross domestic product per head and stroke incidence, and case fatality and the proportion of haemorrhagic strokes. The adverse trends in poor countries are consistent with trends in blood pressure level, which have been falling in high-income countries but increasing in many low-income and middle-income countries.[58]

Actions suggested for stroke prevention are the same as those for ischaemic heart disease. Effective components of acute treatment include antithrombotic treatment with aspirin or thrombolytic treatment (in which case neuroimaging is needed to exclude haemorrhagic stroke). In high-income countries, specialist stroke units provide the best general management of acute stroke. Rehabilitation, including physical, speech, and occupational therapy and counselling, can reduce deaths, disability, and the need for long-term institutional care. However, in the WHO-CHOICE modelling exercise for African and southeast Asian regions, acute treatment for stroke and organised stroke unit care were associated with slight benefits and were not cost effective (>Int$6000 per DALY averted). Greater yields would be obtained through secondary prevention (aspirin, a statin, and an ACE inhibitor and diuretic for greatest gains),[44] but coverage is low in low-income and middle-income countries.[59]

Cancer

Malignant neoplasms accounted for 87·0 million DALYs in older people in 2010, 67% of the burden arising in low-income and middle-income regions. Burden in older people is forecast to increase by 69% to 2030. Cancer is a leading cause of mortality, accounting for 9·9 million deaths yearly of which 5·4 million (54%) occur in people aged 60 years and older.

The incidence of many cancers rises with age. In the UK (2007–09), incidence increases exponentially for men from 116 men per 100 000 at age 40–44 years to 3398 men at age 85 years and older, and from 245 per 100 000 women at age 40–44 years to 2082 women at age 85 years and older; 63% of all cancers were diagnosed in people aged 65 and older.[60] For four cancer sites, most of the DALY global burden is in older people: prostate (89%), oesophagus (52%), colon and rectum (57%), and trachea, bronchus, and lung (57%). The high background prevalence of multimorbidity in older people leads to inadequate suspicion of symptoms. Frailty is rarely assessed in older patients with cancer, but this frailty, rather than age, should inform treatment decisions; age-related variables such as cognitive impairment, falls, and malnutrition have negative associations with cancer survival that are rarely factored into management plans.

According to a *Lancet Oncology* commission in 2011,[61] the ability of high-income countries to deliver affordable cancer care is "at a crossroads" facing a perfect storm of rapidly increased demand driven by population ageing and evermore expensive treatment technologies. The commission advocated policies based on fairness and equity guided by evidence and a departure from an ethos supporting the introduction of treatments providing small incremental benefits irrespective of cost. Rapidly ageing middle-income countries such as China (appendix) face the daunting challenge of addressing the emerging cancer burden in the older population, alongside a growing disease burden from other non-communicable diseases and other pretransition traditional diseases. In China, opportunities for prevention (eg, tobacco control) have not been optimised, there are health-system constraints (restricted coverage of radiotherapy centres) and out-of-pocket payments restrict access to more effective but costly treatment options.[62] In high-income countries, the costs of medical care for older patients with cancer might be lower than for their younger counterparts,[63] partly because community social-care agencies and informal family carers take more responsibility for long-term and end-of-life care. In low-income and middle-income countries, meeting these needs for large numbers of older patients with cancer will place a strain on eroded traditional family support systems, without substantial government provision.

In view of the scarce evidence for cost-effectiveness of cancer control and treatment programmes in low-income and middle-income countries, policymakers have been

advised to "start small, scale smart",[64,65] gaining knowledge from pilot programmes, carefully monitored for efficiency, performance, and effectiveness. Surgical treatment for treatable cancers, such as breast, cervical, and colorectal cancer is likely to be cost effective, as might be adjuvant therapy with conventional radiation and drugs. The WHO-CHOICE economic modelling exercise for African and southeast Asian subregions identified potentially highly cost-effective intervention options for colorectal cancer (screening at age 50 years with colonoscopy followed by treatment) and breast cancer (biannual mammography with treatment of all stages), while acknowledging the health system constraints that preclude scaling-up without substantial infrastructure investment and training.[66] Palliative care, particularly pain relief for patients with cancer in the last months of life is also highly cost effective, with drug costs for oral morphine amounting to only US$216–420 per year of pain-free life gained.[67]

Diabetes

Diabetes mellitus accounted for 22·6 million DALYs in older people in 2010, 80% of the burden arising in low-income and middle-income regions. Burden in older people is forecast to increase by 96% from 2004 to 2030. In NHANES 1999–2002,[68] the prevalence of total (diagnosed and undiagnosed) diabetes increases sharply with age, from 2·4% in people aged 20–39 years to 21·6% in people aged 65 years and older. Prevalence of total diabetes had risen from 5·1% (1988–94) to 6·5% (1999–2002), with the largest increases occurring in the oldest age groups.[68] Few epidemiological studies of diabetes in older people have been done in low-income and middle-income countries. Nationally representative surveys in China in 2007–08[69] and Mexico (Encuesta Nacional de Salud 2000)[70,71] provide age-stratified estimates for older adults. In China, total diabetes prevalence rose from 3·2% (20–39 years of age) to 20·4% for people aged 60 or older.[69] Prevalence was lowest in the least economically developed rural settings. In Mexico, total diabetes prevalence was 1% at 20–29 years of age rising to 23% at ages 60–79 years.[70] From these prevalences, 933 000 (41%) of the 2·3 million people with diabetes in Mexico were estimated to be aged 60 and older.[71]

Diabetes is treated with diet, biguanide, or sulphonylurea drugs or insulin. The WHO-CHOICE modelling exercise identified intensive glycaemic control (glycosylated haemoglobin <7%) combined with retinopathy screening and photocoagulation as highly cost effective for the African and southeast Asian subregions.[44] The detection and control of diabetes in older people is suboptimum. In the USA NHANES surveys, in the proportion of cases that were diagnosed, 70% was similar across all age groups.[68] In the China national survey, no age-stratified data were provided, but in the sample as a whole, only 31% of cases were diagnosed.[69] In a Mexican national survey, the proportion of people diagnosed rose with age, from roughly two-thirds of people under 50 years, reaching 86% of people aged 60–69 years, 87% of people aged 70–79 years, and 80% of people aged 80 years or older. However, the proportion of diagnosed cases controlled was lower in older than in younger participants, 58% in those aged 60–69 years, 45% in those aged 70–79 years and 50% in those aged 80 years or older.[71]

Chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease (COPD) accounted for 43·3 million DALYs in older people in 2010, 86% of the burden arising in low-income and middle-income regions. The global burden was forecast to increase by 89% from 2004 to 2030. In an international multisite survey,[72] the prevalence of COPD was around 10% for people aged 40 years and older, nearly doubling with every 10-year increment of age, to reach 19–47% for men and 6–33% for women aged 70 years and older. The projected large increase in population burden is to be driven, mainly, by population ageing.[73] Smoking is the most important risk factor, according to some estimates,[73] for 90% of the costs of illness. However, there is a substantial prevalence of COPD in non-smokers, and other risk factors such as exposure to biomass fuels and tuberculosis might be important, particularly in low-income and middle-income countries.[74]

The mainstay of treatment is inhaled β-agonists alone or in combination with anticholinergics and inhaled or systemic corticosteroids, with antibiotics for acute exacerbations.[75,76] In low-income and middle-income countries, treatment recommendations have been complicated by the high costs and low availability of imported drugs, and the scarcity of spirometry to stage the illness and monitor treatment responsiveness;[77] however, these limitations might be easing.[76] Standard treatment recommendations do not vary by age, but corticosteroids should be used cautiously in older adults and in settings with high prevalence of tuberculosis. Adherence to inhaled drugs can be an issue too.[75] The cost-effectiveness of standard treatments for COPD in low-income and middle-income countries is low (>Int$10 000 per DALY averted), a conclusion predicated partly on an assumption of persistently high treatment costs.[78]

Visual impairment

Visual impairment (blindness or low vision) accounted for 10·4 million DALYs among older people in 2010, 86% of the burden arising in low-income and middle-income regions. This is a very substantial reduction from the 30·9 million DALYs in the WHO 2004 GBD estimates, which was forecast to increase by 86% by 2030. 186 million of the world's 285 million visually impaired (65%), and 32 million of the world's 39 million blind people (82%) are estimated to be older adults aged

50 years and older; cataracts are the leading cause of blindness in the world, and refractive errors are the leading cause of low vision.[79]

The prevalence of cataracts is strongly age-associated. In most world regions, adults aged 80 years and older either have a cataract or have had cataract surgery. However, prevalence in older people aged 60–64 years seems to be higher in Asian studies than in other regions.[80] The prevalence of unoperated cataracts in people aged 60 years and older was 57·8% (north India site) and 52·9% (south India site) in two large population-based studies.[80] Smoking cessation is the main viable strategy at present for cataract prevention, although several studies from India suggest that use of biomass fuels might also be an important risk factor.[81]

The worldwide prevalence of visual impairment from uncorrected refractive errors rises with increasing age from around 1% at age 5–15 years to 8% for people aged 50 years and older, with a prevalence approaching 20% in older people in south Asia.[82] This finding suggests that 95 million older adults have potentially correctable visual impairment and 6·9 million (3·1 million in India) are functionally blind. In countries where visual impairment is highly prevalent, cataracts in older people from rural areas are an important underlying factor, either due to index myopia, uncorrected aphakia, or insufficient intraocular lens correction.[82]

In the WHO-CHOICE cost-effectiveness analysis,[83] extracapsular cataract extraction with posterior chamber lens implantation was a highly cost-effective intervention, Int$116 and Int$97 per DALY averted, respectively.[83] Scaling up this intervention would also address much of the uncorrected refractive errors within these populations. Nevertheless, cataract surgery coverage is generally low, although very variable between studies, with rural populations and women being particularly underserved.[84,85] The cost-effectiveness of screening for and correcting refractive errors with glasses in older people has not been specifically examined. This is a low-cost intervention—for example, screening, refraction, and dispensing costs in India (for schoolchildren but in primary care) were estimated at US$31.[86]

Dementia

Dementia accounted for 10·0 million DALYs in older people in 2010, 44% of the burden arising in low-income and middle-income regions. This is a substantial reduction from the 18·8 million DALYs in WHO GBD 2004 estimates, which was forecast to increase by 86% by 2030. Dementia is characterised by progressively disabling impairment of several cognitive functions. However, behavioural and psychological symptoms affect quality of life, are an important cause of carer strain,[87] and are a common reason for institutionalisation.[88] In population studies in low-income and middle-income countries, dementia was consistently the leading contributor to disability[50] and dependence.[51]

Early estimates of worldwide prevalence were hampered by an absence of evidence from low-income and middle-income countries. Primary research[89–91] from the past 10 years with culturally valid methods suggests that age-specific prevalence and incidence of dementia is similar to that in high-income countries. As more data emerge, systematic reviews[92,93] show that age-standardised prevalence varies little between world regions (between 5% and 8% of people aged 60 years and over).[93,94] Incidence doubles with every 5·9-year increase in age, from 3 per 1000 person years at age 60–64 years to 175 per 1000 person years at age 95 and older; 7·7 million new cases are expected each year.[95]

The number of people with dementia worldwide will increase sharply, driven by worldwide patterns of population ageing; 44·4 million people had dementia in 2013, with numbers nearly doubling every 20 years to 75·6 million in 2030 and 135·5 million in 2050.[93] Proportionate increases in the next 20 years are predicted to be much steeper in low-income and middle-income countries than in high-income countries. 58% of people with dementia worldwide live in low-income and middle-income countries, which is expected to rise to 71% by 2050. The total estimated worldwide costs of dementia were US$604 billion in 2010, equivalent to 1% of the world's gross domestic product.[96] In low-income countries, informal care costs predominate (58% of all costs in low-income countries and 65% of all costs in middle-income countries, compared with 40% in high-income countries). Conversely, in high-income countries, the direct costs of social care (paid care in the community or in care homes) account for 42% of total costs compared with 14% in low-income countries.

The progressive course of dementia cannot be changed, but symptomatic treatments and support are helpful. Early diagnosis allows patients affected to participate in advanced-care planning while they still have capacity to do so.[97] Education, training, and support for carers is effective in reducing carer strain and psychological morbidity, and, in high-income countries, in delaying or avoiding transition into care homes.[98] Such interventions might be more effective early in the disease course.[97,99] Early diagnosis and intervention is likely to be cost-effective in high-income countries, assuming delayed or averted transfer into costly institutional-care settings.[97] The cost-effectiveness of scaling up diagnosis and care in low-income and middle-income countries is unknown. However, the psychological and economic strain on caregivers is substantial, and compensatory benefits practically non-existent.[87,94] Although worldwide awareness of the need to invest in the development of treatment and care for dementia is growing (eg, the 2013 G8 Summit was devoted to the topic, setting an ambition to identify a disease-modifying treatment for dementia by 2025), substantial challenges in achieving acceptable levels of coverage and access to care exist. At present, people with dementia receive a diagnosis late in the disease course, if

at all; around half of the people affected are diagnosed in high-income countries, the proportion falling to less than 10% in low-income and middle-income countries where awareness is even less than in high-income countries.[97,100]

Musculoskeletal disorders

Musculoskeletal disorders accounted for 43·3 million DALYs in older people in 2010, 66% of the burden arising in low-income and middle-income regions. This is a very substantial increase from the 12·1 million DALYs in WHO 2004 GBD estimates, which were forecast to increase by 70% by 2030. The main contribution from musculoskeletal disorders arises from low-back pain (19·1 million DALYs) followed by osteoarthritis (7·5 million DALYs).

Low-back pain is a syndrome based mainly on self-reported symptoms, with many underlying pathological changes, including mechanical causes (muscle and joint strain, disc degeneration or prolapse, or osteoarthritic and osteoporotic bone disease) with inflammatory back pain accounting for up to a third of cases.[101] Psychosocial factors, such as stress, anxiety, depression, job dissatisfaction, and low social support, predispose to chronicity. In a review of many studies done worldwide, the median (1-month period) prevalence of activity-limiting low-back pain was estimated at 23%, peaking in the working age population, and then decreasing into older age.[102] In older people there might be underascertainment because of cognitive impairment or an increased tolerance or decreased perception of pain. The WHO Scientific Group on Rheumatic Diseases estimated in 2003 that 10–20% of the world's population aged 60 years or older have significant clinical problems attributed to osteoarthritis.[103] Prevalence increases sharply with age, since osteoarthritis is remorselessly progressive and cumulative.[103]

The outlook for chronic low-back pain is poor, and treatment outcomes have not improved, despite increased use of surgical and other invasive techniques.[104]A holistic and conservative approach is suggested by Morlion,[104] with due attention to psychosocial factors. The mainstay of osteoarthritis treatment is self-management (exercise, pacing of activities, joint protection, weight reduction, and other measures to unload damaged joints) and anti-inflammatory analgesics.[105] Paracetamol is the first line pharmacological treatment for both osteaoarthritis and low-back pain in older people, who might be especially susceptible to cardiovascular and gastrointestinal adverse effects of non-steroidal anti-inflammatory drugs (NSAIDs). However, effectiveness of paracetamol for chronic low-back pain has not been clearly proven.[104] NSAIDs, if used at all, should be prescribed with a proton pump inhibitor, or cyclo-oxygenase-2 selective drugs should be considered. Joint replacement is cost-effective for patients with severe symptoms or residual functional impairment on conservative treatment;[106] however, access to this intervention is restricted in resource-poor settings.

Health care

The Madrid International Plan of Action on Ageing called for the elimination of social and economic inequalities in access to health care and the development of healthcare and long-term care to meet the needs of older people.[1] To achieve these needs, age discrimination should be countered and the challenges posed by multimorbidity and frailty addressed. The fitness for purpose of health services and systems for older adults and their complex, interacting, chronic medical and social difficulties is open to question.

Ageist attitudes and beliefs that ill health is inevitable, intervention ineffective, and improved outcomes inherently not valuable are widespread, even in older people and health-care professionals.[107] However, the association between age and health is much more variable than is often realised, and age alone should not determine access to treatment and care. Even in well resourced countries, age discrimination is apparent in primary and secondary prevention of cardiovascular disease,[13,108] treatment of stroke[109] and acute coronary stenosis,[110] and access to surgical procedures.[111] In cancer care, fewer diagnostic and staging procedures are done and less evidence-based treatment is given to older people, even when taking frailty into account.[112] Older people tend to be excluded from clinical trials that would generate specific evidence to inform their treatment, even for drugs that are mainly prescribed in older age.[113] Age discrimination is multifactorial, including demand-side and supply-side factors. Structural barriers are implicated in view of striking differences in service use between health systems that are not attributable to morbidity patterns.[114] These barriers include the high cost of chronic disease care when incomes are insecure; health care is financed by out-of-pocket payments and insurance coverage is incomplete.[114–116]

Multimorbidity increases sharply with age, with around two-thirds of people aged 65 years and older affected,[117–120] and is strongly associated with impaired quality of life,[121] disability, dependence,[122] and mortality.[118] Patients with multimorbidity account for 96% and people with more than five disorders for 68% of USA Medicare expenditure.[123] Care coordination is essential; unnecessary hospital admissions increase exponentially in the USA with increasing multimorbidity.[117,123] Rigid application of clinical practice guidelines for single disorders might contribute to polypharmacy, adverse drug interactions, and unnecessary cost.[124] Frailty provides an attractive theoretical framework within which practitioners can devise holistic assessment and treatment of older people with complex co-morbidities in a structured way.[125,126] Frailty describes a process of progressive age-related deterioration in physiological systems with decreased functional reserve capacity, and hence susceptibility for failure in the face of environmental stressors. Frailty predicts adverse health and social outcomes (morbidity, disability, hospital

admission, falls and fractures, dependence, institutionalisation, and death) better than diagnostic information alone.[127,128] Originally defined as a largely physical construct identified by five indicators (exhaustion, weight loss, weak grip strength, slow walking speed, and low energy expenditure), others have widened the scope to include, for example, cognitive or sensory domains.[129,130] Clusters of frailties or disorders might occur because of common risk factors or underlying pathophysiologies, or because one disorder is a complication of another, or its treatment.[131] Causal links might have implications for primary prevention, disease management and for the efficient delivery of good quality age-appropriate health care.[119,132]

A holistic approach has been advocated, with comprehensive assessment, leading to well integrated continuing care, focusing first and foremost on patient preferences in an effort to streamline care and enhance its acceptability.[131,132] The benefits of comprehensive geriatric assessment and referral were most pronounced in trials done in the 1980s and early 1990s, before such approaches were institutionalised in many high-income countries.[133] Exploration of the role of community-based models of care, individually tailored multicomponent interventions, and various approaches to integrated case management are all active areas for research. Targeting of these areas could be achieved by focusing on the acquisition of frailties that confer risk for adverse outcomes and that might, in principle, be delayed, slowed, or even reversed; the present evidence base is mainly restricted to nutritional and exercise interventions.[134] The added value of such assessments needs to be tested formally, and more work needs to be done to link assessment to evidence-based multidimensional intervention.[126]

Conclusion

The worldwide epidemic of chronic disease is, to a large and increasing extent, concentrated in older people and people living in low-income and middle-income countries. Global burden of disease in older people is projected to increase more or less in line with the increase in the older population, consistent with population ageing being the most important driver of the chronic disease epidemic.[135] The largest increases in disease burden will occur for those disorders that are particularly strongly age-associated (dementia, stroke, COPD, and diabetes). The association between biological age and morbidity and loss of function underpins the link between population ageing and increasing burden; however, this association is neither constant nor immutable, leaving much scope for intervention to promote health and prevent disease in older people.[136] In low-income and middle-income countries, the epidemiological transition will result in growing exposure to cardiovascular risk factors in older people, particularly in poor people, an increase in the incidence and prevalence of cardiovascular diseases, and a surge in health inequalities. To address this issue should be a global health priority. In high-income countries, socioeconomic gradients, once established, tend to become entrenched, with poor people and people with lower levels of education failing to benefit from subsequent improvements in public health.[137] Hence, there are two crucial and related public health challenges for low-income and middle-income countries; can we improve the health of successive cohorts of older people as life expectancy increases (compression of morbidity), and can this be achieved equitably? Monitoring of progress will need increased and improved population-based studies of the health of older people in low-income and middle-income countries.

The age distribution of chronic disease is not adequately shown in the prioritisation of present strategies to combat the epidemic.[138] Although deaths due to ischaemic heart disease occur at younger ages in low-income and middle-income countries, most deaths, and most opportunities to prolong life arise in older people. The focus on primary prevention strategies to reduce midlife mortality neglects the substantial disability and dependence from increased survival with cardiovascular disease. The focus also diverts attention from other disorders such as dementia, stroke, COPD, and vision impairment, for which the burden of disease arises more from disability than from mortality,[50] and for which costs of long-term care outweigh health expenditure.

The societal costs of these disorders is enormous, particularly in high-income countries with welfare-based social care systems; in the UK, the societal cost of dementia is estimated to exceed that of cardiovascular disease, cancer, and diabetes combined.[139] The Institute of Health Metrics and Evaluation (IHME) disability weights used to compute years lived with disability (YLD) have compounded this issue.[140] Seismic shifts in the burden of disease between WHO 2004 estimates[4] and the IHME 2010 estimates[38] have neither been highlighted nor explained. Findings from this Review show that, in older people for whom the discrepancies were most striking, the burden of dementia has been cut by half, the burden of visual impairment by two-thirds, and the burden of musculoskeletal disorders has increased nearly four times. This result is due to changes in disability weights rather than in the estimates of the frequency of these disorders. Disability weights will be affected by choice of respondents used to measure them, the information provided about the health states, and the way that the questions are framed. WHO GBD weights[141] were measured through a consensus of international experts, whereas the IHME weights portrayed judgments of the general public.[140] IHME weights link to relative health rather than relative disability, and the extent to which the IHME GBD notion of health loss maps on to conventional notions of disability and dependence is open to question.

Primary and secondary preventive interventions for cardiometabolic disorders are nearly as effective in older people as in younger people. In view of the increased incidence and prevalence of cardiometabolic disorders in older people, the relative efficiency of these interventions is strengthened. This efficiency is apparent in the much smaller numbers needed to treat to prevent one adverse outcome in older people than in younger people,[28] and is implicitly recognised in treatment algorithms and prevention strategies endorsed on the grounds of cost-effectiveness through WHO-CHOICE modelling exercise.[44] Nevertheless, these strategies are selectively underused in older people. Control of hypertension in older people is a core indicator of the functionality of primary care systems for chronic disease management. Much work still needs to be done to increase coverage, particularly in low-income and middle-income countries,[14] although the issue is not restricted to resource-poor settings.[30] Whether universal or targeted approaches, fixed-dose combination treatment, or antihypertensive drugs alone are used, health-system strengthening is fundamental.

Effective intervention in older people is complicated by ageism, complex multimorbidity, and poor access to age-appropriate care, exacerbated by user fees, inadequate income security, and social protection.[114] Age-appropriate primary care services need to be reorganised and trained, to better meet the needs of their increasingly aged clientele. Reforms should include a commitment to provide continuing care, capacity for outreach including home-based assessments, and holistic integrated care for patients with multimorbidities. Simple structured assessment and attention to underlying frailties (little mobility, undernutrition, pain, incontinence, and cognitive and sensory impairment) might promote increased attention to the needs of older people and limit disability and dependence. Family carers benefit from advice and support, particularly when needs for care are pronounced. The development and evaluation of such models of care is urgently needed, particularly for their cost-effectiveness.

Contributors

All authors worked together to decide the scope and structure of the Review. MP did the analyses of IHME GBD data and wrote the first draft of the manuscript with particular inputs from SY (cardiovascular diseases), M'OD (stroke), RS (cancer), LMGR (frailty and multimorbidity), and FW and YG (China context). All authors reviewed, edited, and approved the final manuscript.

Declaration of interests

We declare no competing interests.

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