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COMPRESSION OR EXPANSION OF DISABILITY?

Forecasting Future Disability Levels under Changing Patterns of Diseases

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Executive summary

By 2020 one in five people in the UK will be aged over 65 years; life expectancy at birth is increasing at the rate of three years every decade. Whether the extra years are spent healthy and independent is still unknown but is of critical interest to the government and to health and social care providers, as well as to older people themselves. The planning of preventive, primary and secondary health services and social and long-term care services for older people requires accurate projections of future need based on reliable estimates of the prevalence and incidence of disability and an understanding of the impact of chronic disease on function.

Using data from the Medical Research Council Cognitive Function and Ageing Study (MRC CFAS) – a nationally representative sample of people aged 65 years and over – we have explored the effect of different health scenarios on the future numbers of older people with disability at a level that needs social care. From a review of four diseases – dementia, stroke, coronary heart disease (CHD) and arthritis – we have developed evidence-based scenarios for the health of the future older population.

Our results show that ageing of the population alone, with no alteration in the prevalence of diseases or the age-specific rates of becoming disabled or recovering, will result in a 67 per cent increase in the numbers with disability over the next 20 years. Numbers of the oldest old (those aged 85 years and over) with disability will have doubled and the numbers experiencing one of the key diseases considered will have increased by over 40 per cent by 2025.

If the emphasis of public health interventions and medical treatments continues to be on extending life at older ages, with little or no consideration for alleviating or postponing the disabling consequences of disease, there will be around 50,000 more older people with disability at a level that needs care by 2025, in addition to the rises resulting from the ageing of the population.

Moderate improvements in population health, from reductions in levels of obesity and other negative health behaviours, and control of vascular risk factors, together with new treatments or technologies focused on reducing the disabling consequences of disease, could considerably reduce the numbers with disability by 2025, with up to 80,000 fewer disabled older people. However, this would make only limited inroads into offsetting population ageing and the numbers of disabled older people would still increase by 57 per cent. It thus seems unlikely that a compression of disability will occur unless the severity of disability associated with diseases diminishes.

We discuss these results in the light of findings from other countries and make recommendations on the data needed to improve future projections.

Introduction

Life expectancy at birth has been increasing by three years every decade for over 100 years with little evidence of the rate slowing down. Attention is now focusing more on the quality of these extra years gained, particularly in terms of healthy active life, which older people themselves view as important in addition to its central role in health and social care use.

Theoretically, there have been three main scenarios for health accompanying the extension in life expectancy: compression of morbidity (Fries 1980), where the onset of chronic ill-health is postponed to a time closer to death; expansion of morbidity (Kramer 1980), where the years gained are through those in poor health being kept alive; and dynamic equilibrium (Manton 1982), where the years gained may be with disability or ill-health but the disability is less severe. At present, in the UK it remains unclear whether the extra years of life lived are in good (compression of morbidity) or poor health (the expansion of morbidity). Within the USA the picture appears much clearer, with most studies now confirming that disability is being compressed into a shorter period of time (Crimmins 2004).

Disability is not necessarily a consequence of ageing. Conceptual models of the disablement process (Verbrugge and Jette 1994) place active pathology or disease at the start of the process. Major causes of disability in later life are known to be the consequences of both acute and chronic diseases and conditions such as cardiovascular and cerebrovascular disease, sensory problems (vision and hearing), arthritis, incontinence, dementia and depression (Stuck *et al* 1999).

Demand on health and social care is strongly linked to disability levels but projections of future need for long-term care have generally begun with disability and assumed that overall prevalence will increase only as a result of the ageing of the population. Falling mortality rates from cardiovascular diseases and the higher incidence of diabetes and cardiovascular disease, in part caused by rising obesity levels, suggest that the assumption of constant age- and sex-specific prevalence rates of disability may not be tenable, particularly in the longer term.

Most simulation models of population health have been concerned only with the consequences for health care costs of changing risk factors and/or treatments and interventions on mortality (Gunning-Schepers 1989; Wolfson 1994) or on the course of a single disease process, for instance dementia (Brookmeyer *et al* 1998; Sloane *et al* 2002). One other simulation model has linked disease and disability in later life (Boult *et al* 1994), although it considered only the effect of a global decrease in the prevalence of diseases of 1 per cent (Boult *et al* 1996).

In our earlier work we began to develop a simulation model (SIMPOP) to project the number of older people with disability under different disease scenarios in a similar

manner to an earlier American model (Boult *et al* 1996). The transition phase of this model quantified the effect of acute and chronic diseases on mortality and the onset of disability (Spiers *et al* 2005) using the Medical Research Council Cognitive Function and Ageing Study (MRC CFAS 1998), a large nationally representative longitudinal study.

It is against this background that the current work was commissioned in order to inform how changing disease patterns might influence disability and therefore the need for care in the future (within this report when we refer to care we mean social care services). This is to ensure consistency with the Personal Social Services Research Unit (PSSRU) expenditure model into which the disability projections feed. More explicitly this addresses the first of the terms of reference for the Wanless Social Care Review – namely 'to examine the demographic, economic, social, health, and other relevant trends over the next 20 years that are likely to affect the demand for and nature of social care for older people (aged 65 and over) in England'. The terms of reference for this paper are shown in the box below.

TERMS OF REFERENCE

1. To review trends in disease and treatment in four areas: stroke, coronary heart disease, dementia and cognitive impairment, and arthritis.

2. To identify how disease patterns will impact on the future levels of disability of older people over the next 20 years.

3. To produce disability prevalence rates within age groups over the next 20 years in a form suitable to input to the PSSRU model of long-term care projections.

Approach

We confined ourselves to a few specific disease areas: stroke and coronary heart disease (CHD), cognitive impairment and dementia, and arthritis. Our previous work suggested that these encompassed a range of relationships with mortality and disability (for example, arthritis has little impact on mortality whereas stroke and to a lesser degree cognitive impairment both have strong relationships with mortality) and had different albeit some joint risk factors (for example, obesity is a strong risk factor for arthritis, stroke, CHD and vascular dementia).

The work took three stages.

- Stage 1 refined and tested the baseline simulation model with no changing disease assumptions to ensure compatibility with the PSSRU model and with Government Actuary Department (GAD) projections. In particular, the transition model linking disease to disability onset and mortality was refitted with a definition of disability compatible with the PSSRU model.
- Stage 2 comprised an extensive review of the evidence over the previous 15 years for efficacy and diffusion of treatments (and in some cases service models) reducing disability and/or mortality in each of the disease areas. From the reviews the team, including three clinical experts, developed disease-specific scenarios as well as more general scenarios involving all or most of the diseases.

- In stage 3 we applied each of the scenarios in the simulation model to produce numbers of older people with and without disability as well as age-specific disability prevalence from 2001 to 2025. The prevalence rates were passed on to the PSSRU team to input into the care expenditure mode (Malley *et al* 2006).

The simulation model and literature review are presented in the second section. Fuller details of the methodology of the simulation model and the complete literature reviews are available from the authors (or accessed via www.hs.le.ac.uk/lnru/indexa/html).

Structure of the report

The remainder of this report is structured as follows:

- the second section describes the data and methodology for the transition and simulation phases of the model
- the third section summarises the literature review of the disease areas that formed the basis for the scenarios
- the fourth section describes the scenarios
- the fifth section presents the numbers of older people with and without disability over the next 30 years under each of the scenarios
- the sixth and final section draws together the conclusions and provides recommendations for the data required to inform future scenarios.

Simulation model

Transition data

We used data from the Medical Research Council Cognitive Function and Ageing Study (MRC CFAS) to model the effect of disease on disability onset and mortality. A full description of the MRC CFAS study design can be found elsewhere (Gunning-Schepers 1989), but of relevance here is that the study was conducted in three urban (Newcastle, Nottingham and Oxford) and two rural (Cambridgeshire and Gwynedd) centres within England and Wales, including both community-dwelling and institutional residents aged 65 years and over, with those aged 75 years being over-sampled. At baseline, 13,004 people were interviewed.

All participants were initially screened by trained interviewers in their current place of residence during 1991–4, using a structured interview. The interview included questions on sociodemographics, general health (including chronic conditions), cognition, smoking, and basic and instrumental activities of daily living (ADLs/IADLs). Surviving participants were interviewed again two years later, about their health and ADL status. MRC CFAS version 7.1 was used for analysis.

Disability measure

The MRC CFAS interviews included items from the modified Townsend activities of daily living scale (Isaacs and Neville 1976), covering the participant's ability to perform nine activities and tasks, including eight ADLs/IADLs. Response categories were 'Yes, with no difficulty', 'Yes, with some difficulty' and 'No, needs help'. The participant's mobility was also rated by the interviewer as usually ambulant non-housebound, usually ambulant housebound, chairfast permanently and bedfast permanently.

The threshold for disability was chosen to match, as closely as possible, to the definition being used by the Personal Social Services Research Unit (PSSRU) – inability to perform at least one ADL without help. Participants were therefore defined as having disability if they were unable to put on shoes and socks, have a bath or all-over wash, or to transfer to and from bed. This threshold gave a similar prevalence of disability by age and sex to the fifth of the six disability groups used in the PSSRU model.

If answers to the first 10 questions in the interview, which addressed orientation, indicated that the participant was disoriented in time or space, only a subset of questions was asked. These participants (n = 235) were coded as disabled for the purposes of this model.

Measures of disease

At baseline, participants were asked if they had ever suffered from a heart attack, angina, intermittent claudication, diabetes, asthma, chronic bronchitis, arthritis, Parkinson's disease, treated hypertension, stroke, emotional problems or underactive thyroid. Angina and intermittent claudication (peripheral vascular disease) were elicited from the Rose Scales (Rose *et al* 1977).

Participants were considered to have coronary heart disease (CHD) if they reported having suffered from a heart attack or angina, or were classified as having angina from the Rose Angina Scale. Participants were classified as having had a stroke if they answered positively to the question 'Have you ever had a stroke that required medical attention?' and also reported that the stroke was diagnosed by a GP or specialist.

Cognitive impairment was assessed using the Mini-Mental State Examination (MMSE) (Folstein *et al* 1975). Missing items were divided according to their nature. 'Don't know', 'No answer' and items that could not be answered as a result of sensory or mobility problems were recoded to zero. For all other items, the full score was recoded to missing, unless the participant could be assigned to an MMSE category unambiguously on the basis of the completed items.

Population data

The baseline UK population aged 65 years and over by two-year age bands were taken from the 1991 Census in England and Wales of the Office for National Statistics.

The new population aged 65–66 years at each two-year interval were obtained from three sources. Population figures for 1992–2000 were taken from the 1991 population figures of the Office for National Statistics, revised in light of the 2001 Census. Figures for the period 2001–2 were taken from the Government Actuary's Department (GAD) 2000-based principal projections, and for 2003 onwards from the GAD 2003-based principal projections, including the 2001 Census revision. The 2003-based principal projections assume improvements in mortality rates.

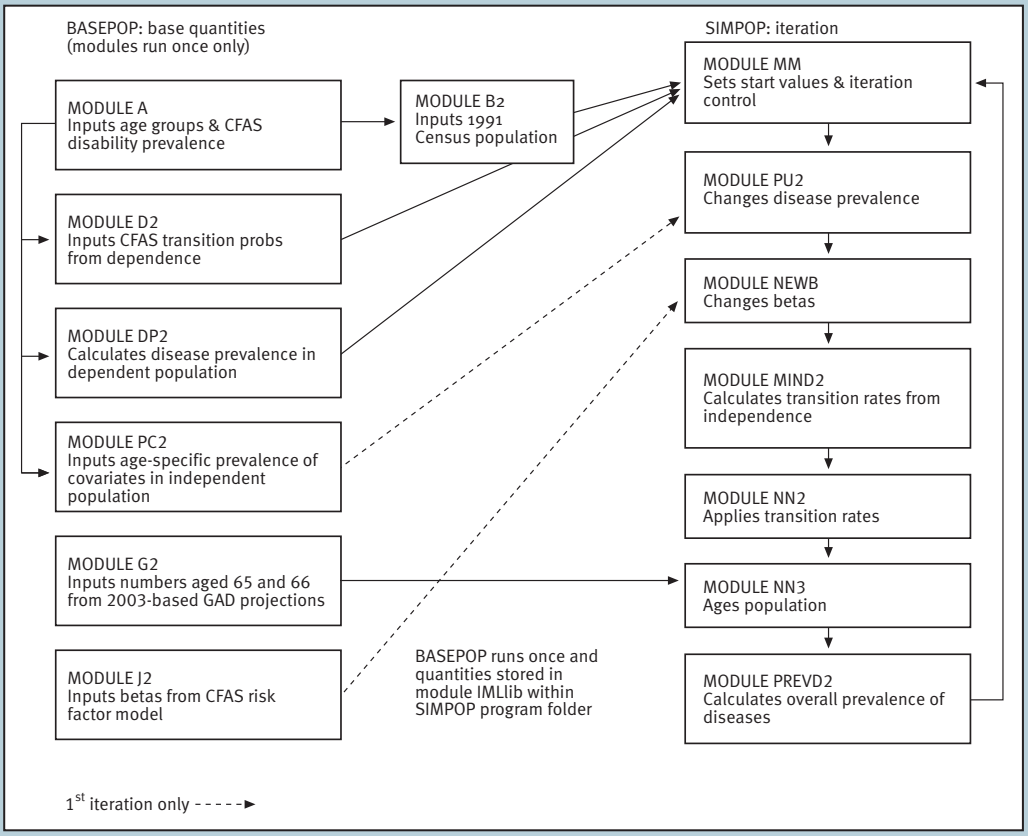
Transition phase

Of the 13,004 participants in the prevalence screen, 12,622 (97.1 per cent) provided sufficient data for their functional status to be classified at baseline; 235 were classified as disoriented after initial orientation questions and therefore classified as disabled at baseline.

A total of 1,366 participants were disabled at baseline, of whom 465 (34.0 per cent) died, 332 (24.3 per cent) were alive and disabled at follow-up and 140 (10.3 per cent) were alive and not disabled at follow-up. Risk factors for improvement were not investigated because of the small number with improved functional status and a relatively high loss to follow-up (31.4 per cent, $n = 429$).

Of the 11,491 participants not disabled at baseline, a total of 8,802 (76.6 per cent) were successfully followed up for functional limitation at two years, of whom 7,389 (83.8 per cent) were not disabled at two years, 472 (5.4 per cent) were disabled and 941 (10.7 per cent) had died.

1 **STRUCTURE OF SIMULATION PROGRAMS, BASEPOP (BASE POPULATION AND INITIAL QUANTITIES), AND SIMPOP (DYNAMIC SIMULATION)**



A trichotomous logistic regression model was fitted to estimate the effects of diseases on the onset of disability and mortality in those not disabled at baseline, using STATA Corporation (STATA 9.0, 4905 Lakeway Drive, College Station, TX 77485, USA). A small number of participants (n = 113) were excluded from the transition model as a result of missing covariates (chronic conditions or sociodemographics), so the model is presented for 8,689 participants.

Projection phase

The simulation was programmed using SAS IML, and consists of two programs: BASEPOP, which sets up the base population and initial quantities, and SIMPOP, which carries out the dynamic simulation. The structures of BASEPOP and SIMPOP can be seen in Figure 1 above.

Transition rates from disability were taken directly as observed from the transition rates between the CFAS prevalence screen and the follow-up two years later.

Transition probabilities from no disability to disability and death are taken from the transition model described earlier using the formulae in the box on p 8.

We further adjusted both sets of transitions (from disability and no disability) to death for every two-year period based on the GAD assumptions, because the GAD population

TABLE 1: TRICHOTOMOUS LOGISTIC REGRESSION MODEL OF SELF-REPORTED DISEASES ASSOCIATED WITH ONSET OF DISABILITY AND DEATH IN THOSE FREE OF DISABILITY AT BASELINE INTERVIEW IN MRC-CFAS (*n* = 8689)

		Onset of disability β (SE)	Death β (SE)
Chronic conditions			
Stroke		0.92 (0.17)	0.64 (0.14)
Peripheral vascular disease		0.21 (0.25)	0.19 (0.16)
Coronary heart disease (angina and heart attack)		0.26 (0.13)	0.56 (0.09)
Treated hypertension		0.13 (0.12)	0.19 (0.09)
Arthritis		0.50 (0.11)	-0.04 (0.08)
Treated diabetes		0.38 (0.22)	0.51 (0.15)
Chronic airways obstruction		0.44 (0.13)	0.25 (0.10)
Parkinson's disease		1.69 (0.35)	1.02 (0.35)
Hearing problems		0.06 (0.12)	-0.002 (0.09)
Eyesight problems		0.64 (0.12)	0.06 (0.10)
MMSE[1]	22–25	0.53 (0.12)	0.65 (0.09)
	0–21	0.96 (0.18)	1.55 (0.13)
Control variables			
Age[2]	70–74 years	0.27 (0.19)	0.48 (0.13)
	75–79 years	0.54 (0.18)	0.86 (0.12)
	80–84 years	1.32 (0.18)	1.24 (0.13)
	85+ years	1.75 (0.20)	1.89 (0.15)
Male sex		-0.10 (0.12)	0.66 (0.09)
Living status[3]	Living with others	0.37 (0.16)	0.21 (0.12)
	Living alone	-0.02 (0.10)	0.11 (0.09)
Social class[4]	III	0.15 (0.12)	0.14 (0.09)
	IV and V	0.27 (0.15)	0.27 (0.11)
	Armed forces personnel/missing	-0.40 (0.37)	-0.32 (0.27)
Smoking[5]	Current smoker	0.02 (0.15)	0.38 (0.10)

[1] versus MMSE 26–30
[2] versus 65–69 years
[3] versus living with spouse
[4] versus social class I and II (I and II = professional and managerial or technical, III = manual and non-manual, IV and V = partly skilled and unskilled)
[5] versus non-smoker

projections make assumptions that death rates will fall in the future. These adjustments may be considered to encompass the impact of diseases that are not considered in the model.

To calculate the numbers dying, becoming disabled and remaining without disability two years later, the transition probabilities of onset and death are multiplied by the number of functionally independent people in each group, in order. The 65- to 66-year age group at each two-year interval are replenished assuming the same prevalence of disability as estimated in MRC CFAS at 1991.

TRANSITION PROBABILITIES TO DISABILITY AND DEATH

$$P(\text{onset of disability}) = \frac{e^{\beta onset \underline{X}}}{1 + e^{\beta onset \underline{X}}}$$

$$P(\text{death}) = \frac{e^{\beta death \underline{X}}}{1 + e^{\beta death \underline{X}}}$$

where β_{onset} and β_{death} are 1 × 23 column vectors containing the betas for transition to functional limitation and death respectively, shown in Table 1 (*see* p 7). $\underline{X}$ is a matrix containing the prevalence of chronic conditions and sociodemographic variables by two-year age group at time t.

TABLE 2: COMPARISON OF POPULATION PROJECTION FROM SIMULATED POPULATION WITH GOVERNMENT ACTUARY DEPARTMENT PROJECTIONS

	Population (thousands)		
	2005	**2015**	**2025**
Simulated population	8,457.4	10,202.5	11,960.6
2002-based principal GAD projection	8,586.1	10,349.9	12,132.4
2003-based principal GAD projection	8,585.0	10,313.2	12,098.3
2004-based principal GAD projection	8,585.6	10,311.1	12,119.9

This process is run iteratively to simulate the future disabled population from 1991 to 2025. Full details of the program and the adjustments to replicate the GAD projections are available (*see* www.hs.le.ac.uk/nccsu).

Comparison with GAD projections

Table 2 above shows that the numbers of people aged 65 years and over simulated using the SIMPOP program, and assuming no change in prevalence or transition rates for any disease, are comparable with those produced by the GAD projections.

Literature review

Methods

The purpose of the review was to address two questions for each of the three diseases.

1. What are the trends in disease prevalence and disease-specific disability (where known) from 1990 to 2005, and how are these projected to develop to 2031:
   - in those aged 65 years and over?
   - in those aged 40 and over who will be aged 65+ years by 2031?
2. What are the new therapies that may impact on disease prevalence and disease-specific disability up to 2031, and what evidence is there for efficacy, cost-effectiveness and diffusion?

Within the models it was possible to adjust three quantities for each disease – the prevalence, the probability of death within a two-year time window, and the probability of becoming disabled within two years – the last two quantities being functions of β_{onset} and β_{death} as shown in the box opposite. The literature review allowed us to weigh evidence on risk factors, preventive strategies and treatments to guide the amount by which these three quantities might change.

We confined the final choice of literature to:

- important risk factors with established trends, where there is good evidence:
  - that the factor is associated with disease, disability or survival with disease
  - on risk factor trends
  - that the factor is applicable to a sufficiently large section of the population to estimate a significant impact over the period 2005–31
- potentially effective preventive strategies and treatments with good evidence:
  - that the preventive factor has beneficial effect on disease incidence, disease-specific disability or survival with disease
  - that the factor is newly applicable to a sufficiently large section of the population to estimate a significant impact over the period 2005–31. 'Applicable' takes into account at-risk population, cost and feasibility.

Two separate searches were undertaken, with additional information from the websites of the National Institute for Health and Clinical Excellence (NICE), the National Service Frameworks and the National Sentinel Audits.

- Medline, Embase and HIMIC and ASSIA were searched for articles on trends in disease published since 2000. The search terms used were trends, futurology, advances, future, twenty-first century and epidemiology. Results were hand searched to identify publications on trends in prevalence, incidence and disease-specific mortality and disability, and new developments in treatment.
- Medline, Embase, Cochrane and DARE (the Database of Abstracts of Reviews of Effects held by the Cochrane collaboration at the University of York) were searched

for reviews published since 1990, to capture evidence for new therapeutic interventions.

We summarise the literature reviews in each disease area below but fuller details are available (*see* www.hs.le.ac.uk/nccsu).

Results

Dementia and cognitive impairment

The box below summarises the results of the literature review for dementia and cognitive impairment. The main finding was that there was no evidence for increasing or decreasing incidence other than might occur through the increase or decrease in cerebrovascular risk factors and treatment.

Most of the literature on the effect of treatments or interventions reported change in cognition with no good numerical data on the impact on daily living or disability.

SUMMARY OF FINDINGS FROM LITERATURE REVIEW FOR DEMENTIA

- Increasing age is the most important risk factor for dementia and in an ageing population will make the greatest contribution to increasing the costs of care.
- An American model predicts a three- to fourfold increase in prevalence of Alzheimer's disease (AD) between 2000 and 2050 without any change in incidence and progression.
- Incidence rates rise exponentially with age, but sex differences in incidence are small, although women may survive longer with AD.
- Evidence on trends is limited, but what there is suggests that incidence is stable.
- The only major established risk factors are cerebrovascular, associated with steeper decline in AD as well as onset of vascular dementia.
- Cholinesterase inhibitors may have a material effect on disease-specific disability rates, but their continued inclusion in NICE guidelines remains in doubt. Service developments to facilitate early diagnosis and drug treatment may themselves have a positive effect on reducing disability.
- Non-steroidal anti-inflammatory drugs (NSAIDs) may offer some protection against AD.
- There is limited evidence for the benefit of other drugs, but long-term effect, safety and cost-effectiveness remain to be established.
- Systematic reviews of non-pharmacological interventions are mostly inconclusive, based on very few good quality studies. However, there is limited evidence for effectiveness of preventive home visits, and of snoezelen, an indoor controlled multi-sensory environment to provide comfort.

Stroke

The results of the literature review for stroke are summarised in the box opposite. The main findings are the continued decreases in stroke mortality with a similar pattern to coronary heart disease (CHD), suggesting shared risk factors, and the potential for reductions in

stroke incidence and recurrence with good control of vascular risk factors such as hypertension.

SUMMARY OF FINDINGS FROM LITERATURE REVIEW FOR STROKE

- Prevalence of cerebrovascular disease (CVD) rises exponentially with age. Stroke mortality is declining.
- Trends in mortality from ischaemic stroke (cerebral infarct) and CHD are similar, suggesting shared risk factors.
- There is good evidence for the effectiveness of statins to reduce the risk of stroke in secondary prevention.
- There is evidence for the use of oral anticoagulants in primary prevention in those with non-valvular atrial fibrillation.
- There is evidence for efficacy of treatments for hypertension on primary prevention of stroke and for secondary prevention with reduction in stroke recurrence.
- There is evidence for the effect of aspirin for primary prevention of myocardial infarction (MI), and ischaemic stroke at a cost of increased risk of haemorrhagic stroke and for secondary prevention in acute ischaemic stroke.
- There is evidence for an effect of rehabilitation (stroke units, therapy-based rehabilitation) on death and dependency after a stroke.

Most of the literature on the effect of treatments or interventions reported dependency and death as a joint outcome, providing little firm conclusions on how treatments might impact on disability.

Coronary heart disease

The results of the literature review for CHD are summarised in the box overleaf. The main findings are the continued decreases in mortality, an apparent reduction in risk factors particularly among obese individuals, and evidence that effective treatments are not reaching certain subgroups of the population, particularly women and older people.

All of the literature on the effect of treatments or interventions reported mortality as the outcome and provided no data on how treatments might impact on disability.

Arthritis

The results of the literature review for arthritis are summarised in the box overleaf. Although the literature for both rheumatoid arthritis and osteoarthritis were reviewed, we considered only osteoarthritis for the purposes of our simulation model because this is the major cause of disability from arthritis at older ages.

The main findings are the lack of data on trends in either incidence or prevalence, although there is some evidence that the impact of rising obesity levels will contribute to an increase in both the incidence and the disabling effects. There was little evidence for the efficacy of treatments.

SUMMARY OF FINDINGS FROM LITERATURE REVIEW FOR CHD

- Data are not perfect, but suggest decreasing incidence of CHD during the 1980s and 1990s, accompanied by earlier diagnosis.
- Case fatality has decreased for MI, and this will contribute to increased incidence of heart failure, although data in England and Wales are sketchy.
- Declines in CHD may be less in women, but data are lacking.
- Declines in CHD in 'white' men may be counterbalanced by substitution of higher rates for men of south Asian ethnicity, but data are lacking.
- Evidence of reduction of risk factors over time, particularly in obese individuals, so there may be a lower impact of rising trends in obesity than previously thought.
- Continued refinement of endovascular and surgical treatments for acute coronary syndrome, and improved risk stratification, will reduce incidence of disability, perhaps with greater gains possible in women.
- Evidence that effective treatments are not reaching women and older patients.

SUMMARY OF FINDINGS FROM LITERATURE REVIEW FOR OSTEOARTHRITIS

- Osteoarthritis (OA) is associated with more limitations in activities of daily living among older people than any other disease.
- Evidence for trends in the prevalence and incidence of OA is lacking.
- Age is the strongest predictor of OA and the total number of people with OA will continue to rise as a result of increasing life expectancy.
- Before age 50, the prevalence of OA is higher in men than in women for most joints. After age 50, women are more likely to have hand, foot and knee arthritis than men.
- The role of oestrogens in causing OA is unclear but likely to be complex: osteoporosis appears to protect against the development of OA but exogenous oestrogens may protect against the progression of established OA.
- There is much evidence for an association with occupational exposure, and evidence for an association with strenuous sporting activities
- More recently, studies have proved that being overweight is a risk factor for the development of OA pathology, and for the development of pain and disability in the presence of pathological changes.
- There is some evidence that exercise in OA patients may have a beneficial effect on disability.
- There is limited evidence for physiotherapy interventions in reducing the impact of OA on activities of daily living.
- There is conflicting evidence on the effect of chondroitin sulphate and glucosamine on OA. Although introduced because of a putative effect on the OA disease process, their effect, if any, appears to be mostly on the symptoms of pain and disability.
- Viscosupplementation with hyaluronan/hylan has beneficial effects on pain, function and patient global assessment.
- Acetaminophen (paracetamol) was less effective overall than NSAIDs in terms of pain reduction and global assessments but both drugs had similar efficacy in terms of improvements in functional status.
- There is no evidence that currently available NSAIDs affect the disease process in OA, but the evidence that does exist for their benefit suggests that it is restricted to symptomatic benefits on pain and improved function.

Even though arthritis is disabling rather than fatal, we did not find a consensus on outcome measures that reflected daily life functioning, although there are moves to address this.

There are two separate but related targets for prevention and treatment: the underlying pathology of the bone and joint (the disease of OA), and the pain and disability associated with the pathology. Apart from joint replacements for those with advanced disease, there is little evidence for the efficacy of treatments for the disease process, although obesity control, physical fitness and reduced occupational stresses on joints should all theoretically reduce incidence or slow progression. Most other interventions are directed at reducing the impact of the disease by symptomatic treatments of pain and disability or by environmental adaptations.

The efforts of pharmaceutical companies include a focus on identifying ways to affect the early triggers of the OA process and on treatments that protect cartilage from degradation or the bone from micro-trauma. It seems plausible to include, as one potential albeit very speculative scenario, the possibility of a new development in this field.

Scenarios

The future numbers of older people with significant disability will depend on the disabling diseases from which they suffer and whether optimal treatments to alleviate or postpone the disablement are both available and widely spread throughout the population in need. As well as considering individual scenarios for the specific diseases – dementia, arthritis, stroke and coronary heart disease (CHD) – we built three combined scenarios based on the literature reviews. These are summarised in the box below.

SUMMARY OF MAIN SCENARIOS

No change: the age-specific prevalence of diseases remains the same, with prevention strategies and effective treatments simply offsetting the negative influences of obesity and other cohort trends that increase the prevalence of stroke and CHD. Incidence of and recovery rates from dependency remain the same with no further effect of treatments. Mortality rates continue to decline at levels commensurate with Government Actuary's Department (GAD) principal projections.

Poorer population health: obesity trends of an annual 2 per cent increase continue. This increases the prevalence of arthritis, stroke, CHD and vascular dementia, but in addition the consequent dependency associated with these diseases. The emergence of ethnic minorities in significant numbers into the older population adds to the prevalence of stroke and CHD. Some prevention strategies are in place but they fail to offset the increasing prevalence. Treatments continue to focus on reducing the mortality from diseases rather than reducing the disabling effects.

Improving population health: individuals are taking their health seriously and there is a decline in risk factors, particularly smoking and obesity. The health service is responsive with high rates of technology uptake for disease prevention and excellent rates of spread of treatments to all who can benefit, particularly in terms of control of vascular risk factors.

The rationale underlying each of the individual disease scenarios and the combined scenarios are detailed below in terms of the changes to the three quantities in the model: the prevalence of the disease, the probability of disease-specific disability onset in terms of β_{onset} and the probability of disease-specific death in terms of β_{death}.

It is assumed that if there is no change in the duration with disease then a change in incidence can be modelled as a change in prevalence.

Given the paucity of data on the impact of interventions on disability in any of the disease areas, we assumed a change of 5 per cent in either β_{onset} or β_{death} to represent a small impact and a change of 10 per cent to represent a moderate impact.

Dementia

Mild cognitive impairment and moderate or worse cognitive impairment were modelled as separate factors in the transition phase. In the scenarios these are generally grouped together as dementia. The scenarios are built around assumptions about a reduction in the incidence of dementia, improvements in survival in those with dementia and a reduction in the disabling consequences of dementia.

Scenario 1

Reductions in the incidence of dementia of 10 per cent (scenario 1a), 25 per cent (scenario 1b) and 50 per cent (scenario 1c) from 2011 reflect assumptions of delayed onset (Brookmeyer *et al* 1998) or better control of hypertension, possibly reducing incidence by up to 50 per cent (Forette *et al* 1998). To simulate delayed onset, the model assumes a reduction in the prevalence of dementia by 2 per cent, 5 per cent and 13 per cent of the previous level every 2 years, from 2011, for mild cognitive impairment (Mini-Mental State Examination [MMSE] score of 22–25) and, from 2015, for moderate or severe dementia (MMSE score of ≤ 21).

Scenario 2

This is an improvement in the length of survival with dementia, in line with the control of vascular risk factors in those with mild cognitive impairment. As mortality is reduced in the model year on year, as for the GAD projections, it is assumed that only a small further reduction would take place and only in those with mild dementia. Thus, this scenario results from a reduction in the transition from mild cognitive impairment to death (β_{death}) of 5 per cent from 2015.

Scenario 3

This is a reduction in the disabling effect of dementia. It has been reported that cholinesterase inhibitors could delay the time to evident functional decline by between six months and a year (Wolfson *et al* 2002; Feldman *et al* 2005). Although this is not presently viewed as a cost-effective treatment (Loveman *et al* 2005), the patent on donepezil will expire in 2010 and the treatment should then be widely available at a lower cost. This scenario is modelled by a 10 per cent reduction in the transitions to disability ($\beta_{disability}$) in those with mild cognitive impairment from 2011.

Scenario 4

This is a composite scenario of the previous ones that is a more realistic scenario for optimum control of vascular risk factors, with not only improved survival of those with dementia (scenario 2) and a delay in the onset of dementia (scenario 1) in those with vascular disease (Feigin *et al* 2005), but also delayed functional loss (scenario 3; DiCarli 2003).

Arthritis

Evidence for trends in the prevalence and incidence of OA is lacking, but recently studies have demonstrated the role of obesity as a risk factor for the development of OA with, for instance, one-third of knee OA being attributable to obesity (Felson *et al* 2000). There is no good evidence for an effective treatment for OA but weight reduction does appear to have a positive effect on it (Felson *et al* 1992). Hence scenarios were linked through to assumptions about future trends in obesity.

Scenario 1

This is an increase in the prevalence of arthritis on the basis that obesity has contributed to around 20 per cent of arthritis (Leveille *et al* 2005), obesity doubles the risk of disability in those with arthritis (Okoro *et al* 2004) and obesity prevalence has increased by around 2 per cent a year over the last decade (Health Survey for England 2003). This is modelled as an increase in the prevalence of arthritis by 2 per cent every 10 years or 0.5 per cent every 2 years from 2001, and an increase in the transition to disability in those with arthritis ($\beta_{disability}$) by 10 per cent from 2001.

Scenario 2

This is a reduction in the levels of obesity in line with improved health behaviours, with a positive impact on the prevalence of arthritis and its disabling effects. It is assumed that this would take some time to take effect at a population level. This is modelled as a reduction in the prevalence of arthritis of 2 per cent every 2 years from 2011 and a reduction in the transition to disability ($\beta_{disability}$) by 10 per cent from 2011.

Stroke and coronary heart disease

Stroke and CHD are considered jointly, as trends in mortality from ischaemic stroke and CHD are similar, suggesting shared risk factors, and many drug treatments are effective in both. The scenarios were built around assumptions of continuing reductions in case fatality but no reduction in the disabling consequences, a concerted effort to reduce vascular risk factors and obesity in line with the population being engaged in good health behaviours, and a continuance of obesity trends in addition to the focus remaining on reducing mortality rather than reducing the disabling effects of stroke or CHD.

Scenario 1

This is further reductions in case fatality from stroke and CHD above and beyond GAD projections, but no reduction in disabling consequences. This is modelled through a small further reduction in the stroke and CHD disease-specific transition to death (β_{death}) by 5 per cent from 2015.

Scenario 2

This is reduction in stroke and CHD risk, recurrent stroke (a marker for disability) and mortality through intensive hypertension control. The strength of obesity as a risk factor for CHD (and stroke) suggests that reducing the levels of obesity would have a positive impact on the incidence (and therefore the prevalence) of CHD and stroke, and on their disabling consequences, through reductions in recurrent stroke. This is modelled as a reduction in

the prevalence of stroke and CHD by 2 per cent per year from 2011, together with a moderate reduction in the transition to disability ($\beta_{disability}$) by 10 per cent from 2011, and a small further (over and above that included in the GAD projections) reduction in disease-specific mortality (β_{death}) by 5 per cent from 2015.

Scenario 3

This is increases in the prevalence of stroke and CHD, in line with rising levels of obesity; decreasing mortality from stroke and CHD remains the focus for treatments, with a consequent further small reduction in mortality evident by 2015, but a rise in the disabling consequences. This is modelled as an increase in the prevalence of both stroke and CHD by 0.5 per cent per year from 2001, together with a moderate increase in the transition to disability ($\beta_{disability}$) by 10 per cent from 2001 and a further small reduction in disease-specific mortality (β_{death}) by 5 per cent from 2015.

Results

No-change scenario

Between 2005 and 2025 the population aged 65 years and over will increase by 41 per cent from 8,457,000 to 11,961,000. The largest growth in the older population will be in those aged 85 years and over, with numbers rising by 87 per cent (Table 3).

TABLE 3: SIMULATED TOTAL AND DISABLED POPULATIONS BY AGE UNDER THE ASSUMPTION OF NO CHANGE IN AGE-SPECIFIC PREVALENCE OF DISEASE, INCIDENCE AND RECOVERY RATES TO DISABILITY, AND MORTALITY RATES CONTINUING TO DECLINE AT LEVELS COMMENSURATE WITH GAD PRINCIPAL PROJECTIONS

	Population (thousands)				
	2005	**2011**	**2015**	**2021**	**2025**
65–74 years					
Total population	4,403	4,854	5,519	5,799	5,803
Disabled population	195	217	246	269	264
% disabled	*4.43*	*4.46*	*4.45*	*4.64*	*4.55*
75–84 years					
Total population	3,048	3,074	3,247	3,712	4,276
Disabled population	324	332	355	408	464
% disabled	*10.64*	*10.81*	*10.92*	*10.98*	*10.86*
85+ years					
Total population	1,006	1,290	1,437	1,693	1,881
Disabled population	348	455	524	640	717
% disabled	*34.62*	*35.30*	*36.49*	*37.78*	*38.13*
All 65+ years					
Total population	8,457	9,217	10,202	11,205	11,961
Disabled population	868	1,004	1,125	1,316	1,446
% disabled	*10.26*	*10.90*	*11.02*	*11.75*	*12.09*

As a result of the continued ageing of the older population, the numbers with disability will increase by 67 per cent from 868,000 to 1,446,000. The majority of these will be in the oldest age groups, the numbers of those aged 85 years and over with disability more than doubling in the next 20 years.

By 2025 the proportion of the older population with disability will have risen by 2 per cent to 12.1 per cent.

Under the no-change scenario, the number of people aged 65 years and over who have experienced a stroke would increase by 46 per cent, from 601,000 in 2005 to 878,000 in 2025 (*see* Table 4 below). Over the same period, the numbers with coronary heart disease (CHD) would increase by 42 per cent (from 1,808,000 to 2,566,000), the number with arthritis would increase by 42 per cent (from 4,354,000 to 6,194,000) and the numbers with mild cognitive impairment would increase by 43 per cent (from 1,807,000 to 2,591,000).

TABLE 4: SIMULATED PREVALENCE OF DISEASE BY AGE UNDER THE ASSUMPTION OF NO CHANGE IN AGE-SPECIFIC PREVALENCE OF DISEASE, INCIDENCE AND RECOVERY RATES TO DISABILITY, AND MORTALITY RATES CONTINUING TO DECLINE AT LEVELS COMMENSURATE WITH GAD PRINCIPAL PROJECTIONS

	Percentage of disease prevalence (thousands)				
	2005	**2011**	**2015**	**2021**	**2025**
Stroke					
65–74 years	5.4 (238)	5.4 (262)	5.4 (297)	5.5 (317)	5.4 (315)
75–84 years	8.8 (268)	8.8 (272)	8.9 (287)	8.9 (329)	8.8 (378)
85+ years	9.5 (95)	9.6 (123)	9.7 (139)	9.8 (166)	9.9 (185)
Total	**7.1 (601)**	**7.1 (657)**	**7.1 (724)**	**7.3 (812)**	**7.3 (878)**
Coronary heart disease					
65–74 years	19.9 (877)	19.9 (965)	19.8 (1,095)	20.0 (1,162)	19.9 (1,156)
75–84 years	23.3 (709)	23.3 (715)	23.3 (755)	23.3 (864)	23.3 (994)
85+ years	22.1 (222)	22.1 (285)	22.1 (318)	22.1 (374)	22.1 (416)
Total	**21.4 (1,808)**	**21.3 (1,965)**	**21.3 (2,168)**	**21.4 (2,399)**	**21.5 (2,566)**
Arthritis					
65–74 years	48.1 (2,116)	48.0 (2,330)	48.0 (2,647)	48.2 (2,795)	48.1 (2,789)
75–84 years	55.0 (1,677)	55.0 (1,691)	55.0 (1,786)	55.0 (2,042)	55.0 (2,350)
85+ years	55.8 (561)	55.8 (720)	55.9 (804)	56.0 (948)	56.0 (1,054)
Total	**51.5 (4,354)**	**51.4 (4,741)**	**51.3 (5,237)**	**51.6 (5,785)**	**51.8 (6,194)**
Mild cognitive impairment					
65–74 years	15.4 (676)	15.3 (742)	15.2 (841)	15.5 (901)	15.4 (892)
75–84 years	27.7 (844)	27.7 (850)	27.6 (896)	27.5 (1,022)	27.4 (1,174)
85+ years	28.5 (286)	28.4 (366)	28.2 (405)	28.0 (474)	28.0 (526)
Total	**21.4 (1,807)**	**21.3 (1,959)**	**21.0 (2,142)**	**21.4 (2,397)**	**21.7 (2,591)**
Moderate cognitive impairment					
65–74 years	3.1 (136)	3.1 (150)	3.1 (170)	3.2 (184)	3.1 (181)
75–84 years	10.7 (326)	10.7 (330)	10.7 (348)	10.7 (396)	10.6 (451)
85+ years	36.2 (364)	36.5 (471)	36.9 (531)	37.4 (634)	37.6 (707)
Total	**9.8 (827)**	**10.3 (950)**	**10.3 (1,048)**	**10.8 (1,214)**	**11.2 (1,339)**

Poorer population health

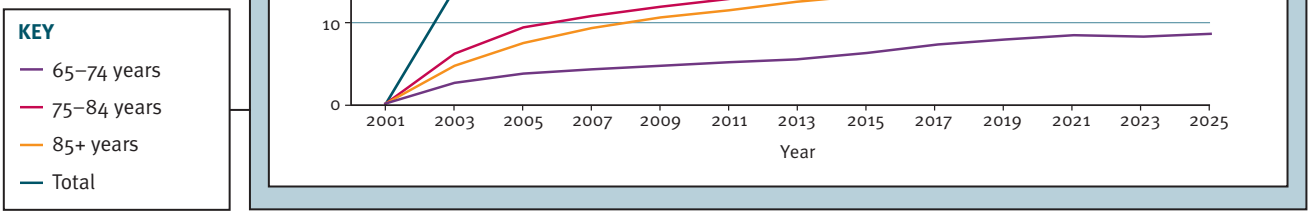
Under the assumption of poorer population health, increases in the size of the older population overall and within age groups are similar to those for the no-change scenario. However, the numbers with disability increase by 69 per cent to 1,504,000 by 2025 and the numbers aged 85 years and over with disability more than double (*see* Table 5 below). Thus poorer population health results in greater numbers with disability compared with the no-change scenario (*see* Figure 2 opposite).

TABLE 5: SIMULATED TOTAL AND DISABLED POPULATIONS BY AGE UNDER THE ASSUMPTION OF POORER POPULATION HEALTH*

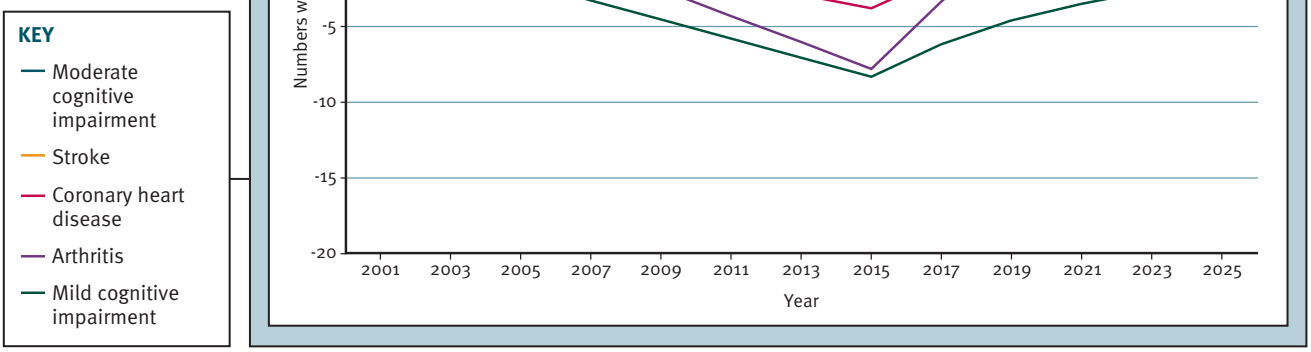
	Population (thousands)				
	2005	**2011**	**2015**	**2021**	**2025**
65–74 years					
Total population	4,402	4,852	5,517	5,801	5,805
Disabled population	199	222	252	277	273
% disabled	*4.52*	*4.57*	*4.57*	*4.78*	*4.70*
75–84 years					
Total population	3,047	3,069	3,239	3,713	4,281
Disabled population	334	345	370	428	490
% disabled	*10.95*	*11.25*	*11.41*	*11.51*	*11.43*
85+ years					
Total population	1,005	1,287	1,425	1,689	1,880
Disabled population	356	467	538	659	742
% disabled	*35.41*	*36.42*	*37.74*	*39.01*	*39.47*
All 65+ years					
Total population	8,454	9,203	10,181	11,203	11,965
Disabled population	888	1,034	1,160	1,364	1,504
% disabled	*10.51*	*11.24*	*11.39*	*12.17*	*12.57*

* Poorer population health: prevalence of arthritis, stroke and coronary heart disease increases by 0.5 per cent every two years from 2001, transition rates to disability increase by 10 per cent for arthritis, stroke and coronary heart disease from 2001, and mortality rates from disability decrease by 5 per cent for mild dementia, stroke and coronary heart disease from 2015.

2 CHANGE IN NUMBERS OF DISABLED OLDER PEOPLE UNDER SCENARIO OF POORER POPULATION HEALTH COMPARED WITH THE NO-CHANGE SCENARIO, 2001 TO 2025



3 CHANGE IN NUMBERS WITH DISEASE UNDER SCENARIO OF POORER POPULATION HEALTH COMPARED WITH THE NO-CHANGE SCENARIO (AGEING OF POPULATION ONLY), 2001 TO 2025



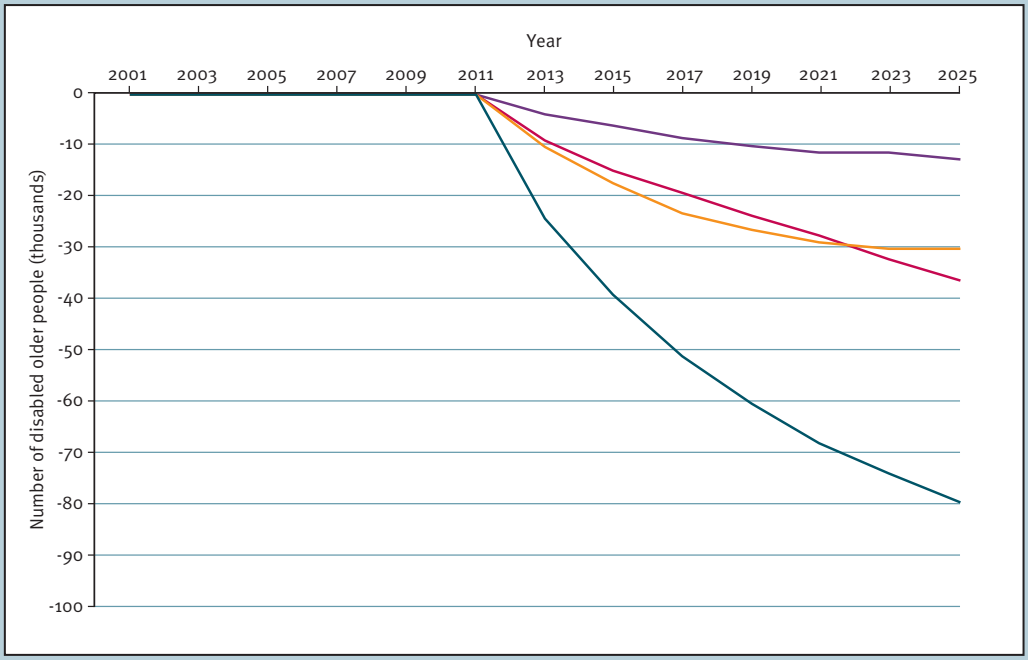
The numbers with disease increase slightly compared with the scenario of no change (*see* Figure 3, p 21). The highest increase is in the numbers with moderate or severe cognitive impairment, with a rise of 20,000 compared with the no-change scenario.

Improving population health

Under the assumption of improving population health, the size of the older population as a whole will increase by 44 per cent to 12,168,000, whereas that of those aged 85 years and over will almost double, reaching 1,996,000 by 2025.

The numbers with disability will continue to grow as the population ages (*see* Table 6 opposite), but by less than the other two scenarios, the percentage increase being 57 per cent between 2005 and 2025 (*see* Figure 4 below). By 2025 the proportion of the older population with disability will be 11.2 per cent, a rise of around 1 per cent over 20 years. Again the largest increases in both the numbers and the proportion with disability will be in those aged 85 years and over; by 2025 687,000 people in this age group will have disability, an increase of 97 per cent from 2005.

4 **CHANGE IN NUMBERS OF DISABLED OLDER PEOPLE UNDER SCENARIO OF IMPROVING POPULATION HEALTH COMPARED WITH THE NO-CHANGE SCENARIO, 2001 TO 2025**



KEY
- 65–74 years
- 75–84 years
- 85+ years
- Total

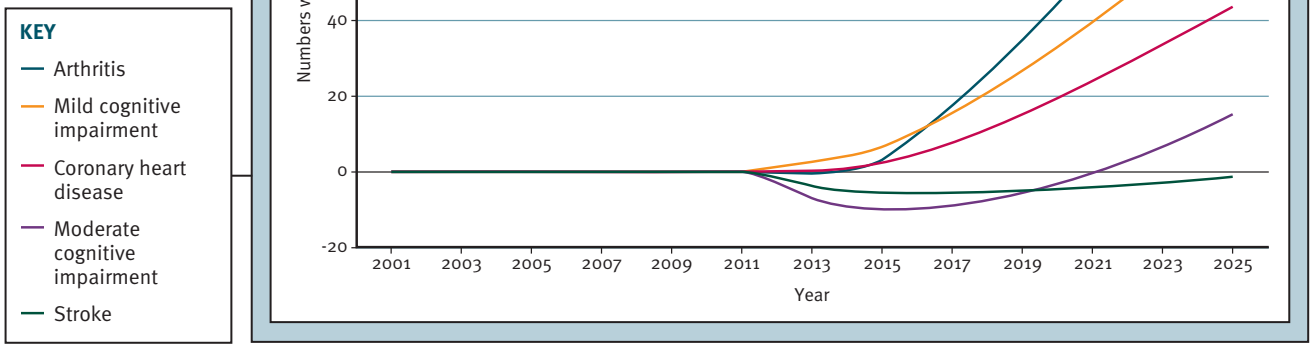
Although improving population health will reduce the numbers with disease, these will not, apart from stroke, offset the increases resulting from the ageing of the population (*see* Figure 5 opposite). The number of people with arthritis will increase the most, with 102,000 more by 2025 compared with the scenario of no change.

TABLE 6: SIMULATED TOTAL AND DISABLED POPULATIONS BY AGE UNDER THE ASSUMPTION OF IMPROVING POPULATION HEALTH*

	Population (thousands)				
	2005	**2011**	**2015**	**2021**	**2025**
65–74 years					
Total population	4,403	4,854	5,521	5,814	5,821
Disabled population	195	217	239	257	251
% disabled	*4.43*	*4.46*	*4.33*	*4.43*	*4.32*
75–84 years					
Total population	3,048	3,074	3,252	3,754	4,352
Disabled population	324	332	339	380	428
% disabled	*10.64*	*10.81*	*10.44*	*10.12*	*9.83*
85+ years					
Total population	1,006	1,290	1,444	1,753	1,996
Disabled population	348	455	507	611	687
% disabled	*34.62*	*35.30*	*35.11*	*34.84*	*34.40*
All 65+ years					
Total population	8,457	9,217	10,217	11,322	12,168
Disabled population	868	1,004	1,086	1,248	1,366
% disabled	*10.26*	*10.90*	*10.62*	*11.02*	*11.22*

* Improving population health: prevalence of arthritis, stroke, coronary heart disease and mild dementia decreases by 2 per cent every two years from 2011, moderate dementia decreases by 2 per cent every two years from 2015, transition rates to disability decrease by 10 per cent for arthritis, stroke, coronary heart disease and mild dementia from 2011, and mortality rates from disability decrease by 5 per cent for mild dementia, stroke and coronary heart disease from 2015.

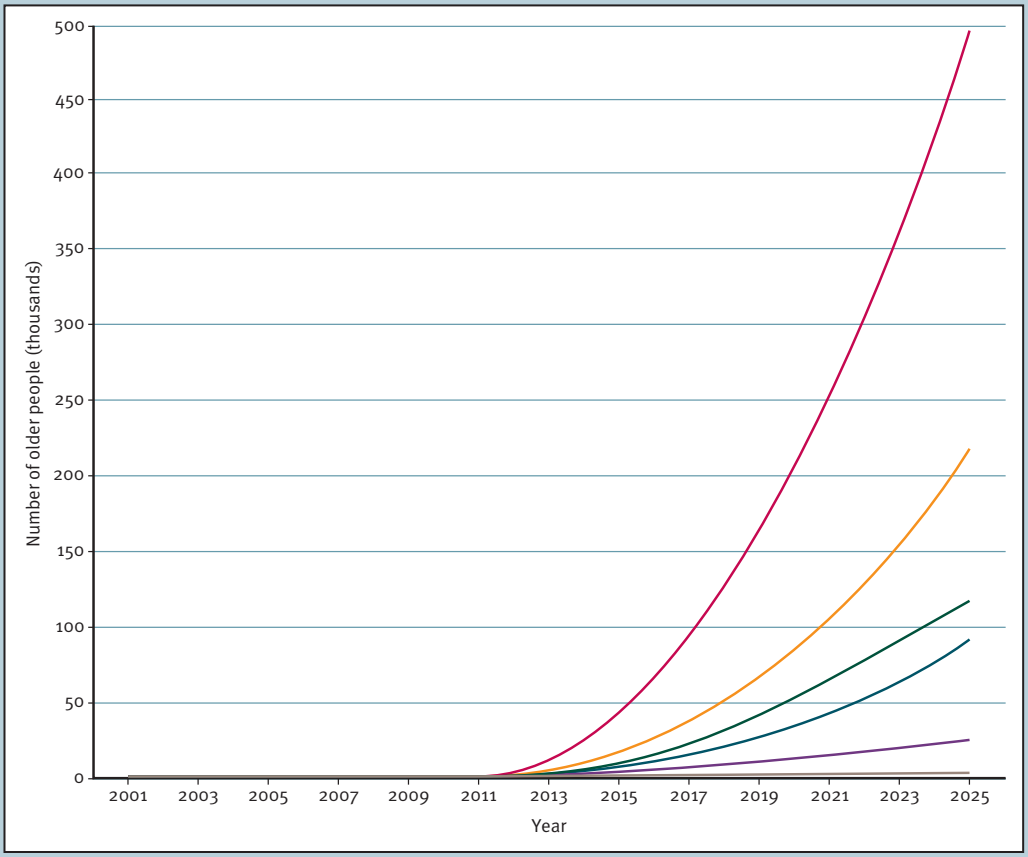
5 CHANGE IN NUMBERS WITH DISEASE UNDER SCENARIO OF IMPROVING POPULATION HEALTH COMPARED WITH THE NO-CHANGE SCENARIO (AGEING OF POPULATION ONLY), 2001 TO 2025



Dementia

Decreasing the prevalence of dementia by just 2 per cent would decrease the size of the disabled population by 11,000 compared with the assumption of no change, and increase the total population by 100,000 by 2025. The proportion of the population aged 65 and over with disability would thus reduce slightly. If the prevalence were decreased by 13 per cent, the disabled population would decrease by 60,000 by 2025, compared with the assumption of no change, and the total population would increase by 450,000, resulting in a 1 per cent decrease in the proportion of the total population with disability.

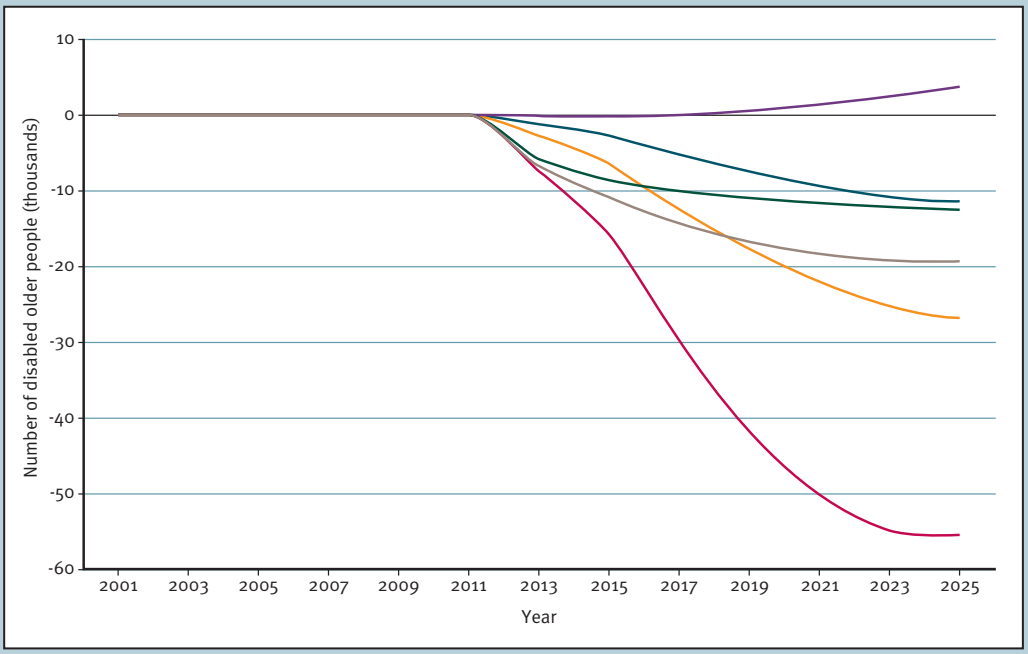
6 **CHANGE IN TOTAL NUMBERS OF OLDER PEOPLE UNDER SCENARIOS OF DIFFERING DEMENTIA TRENDS COMPARED WITH THE NO-CHANGE SCENARIO (AGEING OF POPULATION ONLY), 2001 TO 2025**



KEY

- Scenario 1a: Mild cognitive impairment decreased by 2% every 2 years from 2011, moderate cognitive impairment decreased by 2% every 2 years from 2015
- Scenario 1b: Mild cognitive impairment decreased by 5% every 2 years from 2011, moderate cognitive impairment decreased by 5% from 2015
- Scenario 1c: Mild cognitive impairment decreased by 13% every 2 years from 2011, moderate cognitive impairment decreased by 13% from 2015
- Scenario 2: Transition rate to death decreased by 5% from 2015 for mild cognitive impairment
- Scenario 3: Transition rate to disability decreased by 10% from 2011 for mild cognitive impairment
- Scenario 4: Prevalence of mild cognitive impairment decreased by 2% every 2 years from 2011, moderate cognitive impairment decreased by 2% every 2 years from 2015; transition rate to disability decreased by 10% from 2011 and to death decreased by 5% from 2015 for mild cognitive impairment only

7 **CHANGE IN NUMBERS OF DISABLED OLDER PEOPLE UNDER SCENARIOS OF DIFFERING DEMENTIA TRENDS COMPARED WITH THE NO-CHANGE SCENARIO (AGEING OF POPULATION ONLY), 2001 TO 2025**



KEY

- Scenario 1a: Mild cognitive impairment decreased by 2% every 2 years from 2011, moderate cognitive impairment decreased by 2% every 2 years from 2015
- Scenario 1b: Mild cognitive impairment decreased by 5% every 2 years from 2011, moderate cognitive impairment decreased by 5% from 2015
- Scenario 1c: Mild cognitive impairment decreased by 13% every 2 years from 2011, moderate cognitive impairment decreased by 13% from 2015
- Scenario 2: Transition rate to death decreased by 5% from 2015 for mild cognitive impairment
- Scenario 3: Transition rate to disability decreased by 10% from 2011 for mild cognitive impairment
- Scenario 4: Prevalence of mild cognitive impairment decreased by 2% every 2 years from 2011, moderate cognitive impairment decreased by 2% every 2 years from 2015; transition rate to disability decreased by 10% from 2011 and to death decreased by 5% from 2015 for mild cognitive impairment only

Increasing the survival of those with dementia would lead to an increase of 25,000 in the total population by 2025 compared with the assumption of no change, with a corresponding increase in the size of the dependent population, implying that those who would live longer would live with disability.

Reducing the disabling consequences of dementia would lead to a decrease in the size of the dependent population, but little change in the total population, so the proportion with disability would decrease slightly.

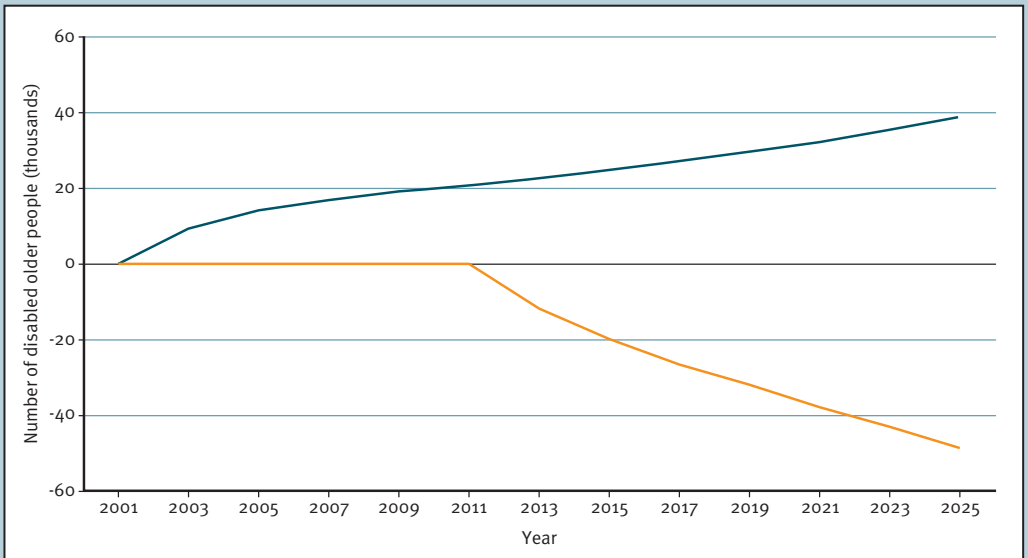
For scenario 4, where it is assumed that the UK experiences delayed onset of dementia in those with vascular disease, improved survival with dementia, as well as delayed functional loss, there would be an increase in the total population of 119,000 by 2025 compared with assuming no change, and a decrease in the disabled population of 19,000. Thus the proportion with disability would decrease by 0.4 per cent.

The effect of the different dementia scenarios on the size of the older population in total as well as the numbers with disability, over and above that caused by the ageing of the population, are shown in Figure 6 (*see* p 24) and Figure 7 (*see* p 25).

Arthritis

Increasing the prevalence of arthritis by 0.5 per cent as well as the disabling consequences would lead to a rise of 39,000 in the dependent population by 2025, over and above the increases caused by ageing of the population (*see* Figure 8 below), with the greatest difference being seen in those aged 75 years and over.

8 **CHANGE IN NUMBERS OF DISABLED OLDER PEOPLE UNDER SCENARIOS OF DIFFERING ARTHRITIS TRENDS COMPARED WITH THE NO-CHANGE SCENARIO (AGEING OF POPULATION ONLY), 2001 TO 2025**



KEY

- Scenario 1: Prevalence increased by 0.5% every 2 years from 2001; transition rate to disability increased by 10% from 2001
- Scenario 2: Prevalence increased by 2% every 2 years from 2011; transition rate to disability decreased by 10% from 2011

Decreasing the prevalence of arthritis by 2 per cent, and reducing the disabling consequences, would lead to a decrease of 50,000 in the numbers disabled by 2025, resulting in a 0.4 per cent decrease in the proportion of the population with disability compared with no change (*see* Figure 8 above). This difference in the proportion with disability would be greatest for those aged 85 years and over.

TABLE 7: SIMULATED TOTAL AND DISABLED POPULATIONS BY AGE GROUP FOR ARTHRITIS SCENARIO 1*

	Population (thousands)				
	2005	**2011**	**2015**	**2021**	**2025**
65–74 years					
Total population	4,403	4,853	5,519	5,799	5,803
Disabled population	198	220	251	275	270
% disabled	*4.49*	*4.54*	*4.54*	*4.74*	*4.66*
75–84 years					
Total population	3,048	3,072	3,245	3,710	4,274
Disabled population	331	341	365	421	48
% disabled	*10.85*	*11.11*	*11.25*	*11.36*	*11.26*
85+ years					
Total population	1,005	1,287	1,432	1,687	1,874
Disabled population	354	464	535	653	733
% disabled	*35.16*	*36.05*	*37.32*	*38.71*	*39.13*
All 65+ years					
Total population	8,456	9,212	10,196	11,196	11,951
Disabled population	882	1,026	1,150	1,349	1,485
% disabled	*10.43*	*11.13*	*11.28*	*12.05*	*12.42*

* Arthritis scenario 1: prevalence increases by 0.5 per cent every 2 years from 2001, and transition rates from independent to disabled increase by 10 per cent from 2001.

TABLE 8: SIMULATED TOTAL AND DISABLED POPULATIONS BY AGE GROUP FOR ARTHRITIS SCENARIO 2*

	Population (thousands)				
	2005	**2011**	**2015**	**2021**	**2025**
65–74 years					
Total population	4,403	4,854	5,519	5,799	5,802
Disabled population	195	217	242	262	256
% disabled	*4.43*	*4.46*	*4.38*	*4.52*	*4.42*
75–84 years					
Total population	3,048	3,074	3,247	3,713	4,277
Disabled population	324	332	347	393	444
% disabled	*10.64*	*10.81*	*10.68*	*10.57*	*10.38*
85+ years					
Total population	1,006	1,290	1,437	1,696	1,886
Disabled population	348	455	516	623	696
% disabled	*34.62*	*35.30*	*35.89*	*36.75*	*36.90*
All 65+ years					
Total population	8,457	9,217	10,203	11,208	11,966
Disabled population	868	1,004	1,104	1,278	1,396
% disabled	*10.26*	*10.90*	*10.82*	*11.40*	*11.67*

* Arthritis scenario 2: prevalence reduces by 2 per cent every 2 years from 2011, and transition rates from independent to disabled reduce by 10 per cent from 2011.

Stroke and coronary heart disease

A further decrease in the case fatality for stroke or CHD would increase the total population by 25,000 by 2025, over and above that caused by the ageing of the population (*see* Figure 9 opposite). The disabled population would, however, also rise, although the proportion with disability would rise only slightly (*see* Table 10 below, and Figure 10, p 30).

TABLE 9: SIMULATED TOTAL AND DISABLED POPULATIONS FOR DIFFERING SCENARIOS OF STROKE AND CORONARY HEART DISEASE TRENDS

	Population (thousands)				
	2005	**2011**	**2015**	**2021**	**2025**
Scenario 1[1]					
Total population	8,457	9,217	10,202	11,221	11,986
Disabled population	868	1,004	1,125	1,318	1,449
% disabled	*10.26*	*10.90*	*11.02*	*11.74*	*12.09*
Scenario 2[2]					
Total population	8,457	9,217	10,209	11,253	12,042
Disabled population	868	1,004	1,116	1,304	1,434
% disabled	*10.26*	*10.90*	*10.93*	*11.59*	*11.91*

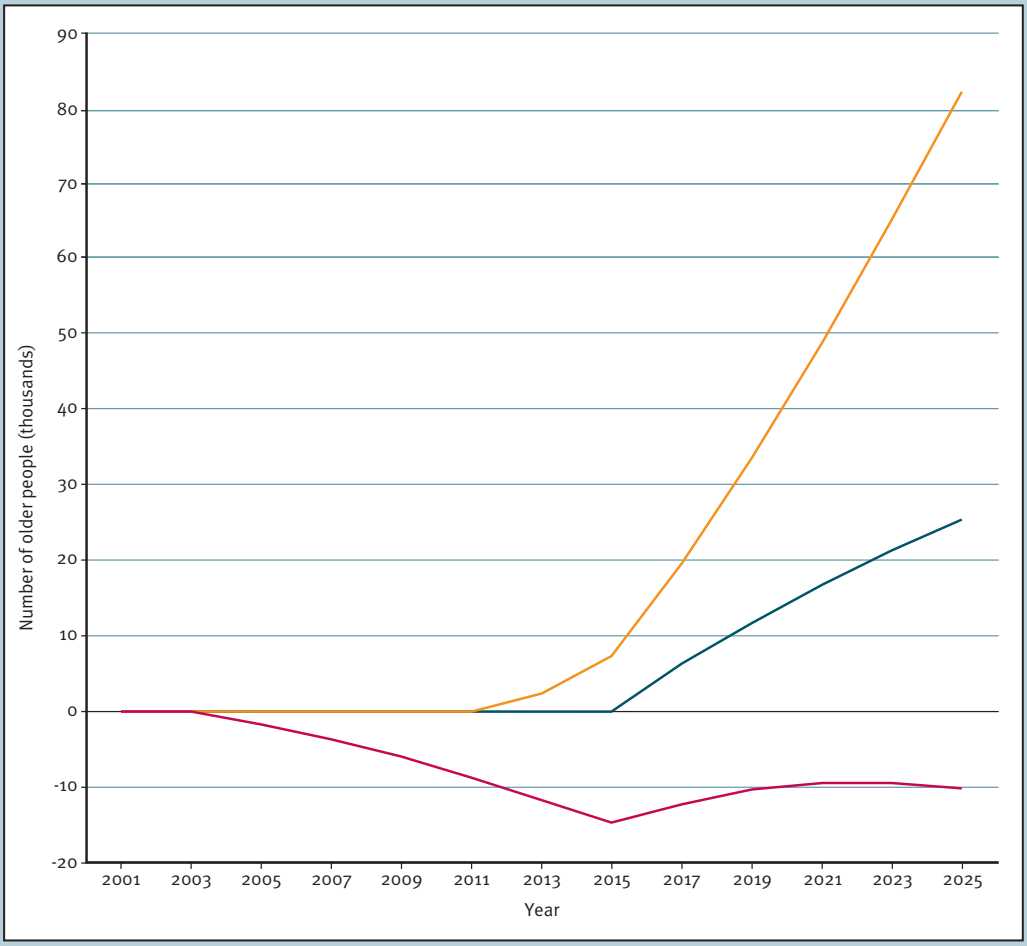
[1] Transition from independent to death decreases by 5 per cent for stroke and coronary heart disease from 2015.
[2] Prevalence decreases by 2 per cent per year from 2011, transition rates from independent to disabled decrease by 10 per cent from 2011, and transition rates from independent to death decrease by 5 per cent from 2015.

TABLE 10: SIMULATED TOTAL AND DISABLED POPULATIONS BY AGE GROUP FOR STROKE AND CORONARY HEART DISEASE SCENARIO 3*

	Population (thousands)				
	2005	**2011**	**2015**	**2021**	**2025**
65–74 years					
Total population	4,403	4,852	5,517	5,799	5,802
Disabled population	196	218	248	271	266
% disabled	*4.46*	*4.49*	*4.49*	*4.68*	*4.59*
75–84 years					
Total population	3,048	3,070	3,241	3,709	4,273
Disabled population	327	336	359	413	471
% disabled	*10.73*	*10.95*	*11.07*	*11.14*	*11.03*
85+ years					
Total population	1,005	1,286	1,430	1,687	1,874
Disabled population	351	459	528	644	723
% disabled	*34.87*	*35.66*	*36.90*	*38.17*	*38.57*
All 65+ years					
Total population	8,455	9,208	10,188	11,195	11,950
Disabled population	874	1,013	1,134	1,328	1,461
% disabled	*10.33*	*11.00*	*11.13*	*11.87*	*12.22*

* Coronary heart disease scenario 3: prevalence increases by 0.5 per cent every 2 years from 2001, transition rates from independent to disabled increase by 10 per cent from 2011, and transition rates from independent to death decrease by 5 per cent from 2015.

9 CHANGE IN TOTAL NUMBERS OF OLDER PEOPLE UNDER SCENARIOS OF DIFFERING STROKE AND CORONARY HEART DISEASE TRENDS COMPARED WITH THE NO-CHANGE SCENARIO (AGEING OF POPULATION ONLY), 2001 TO 2025

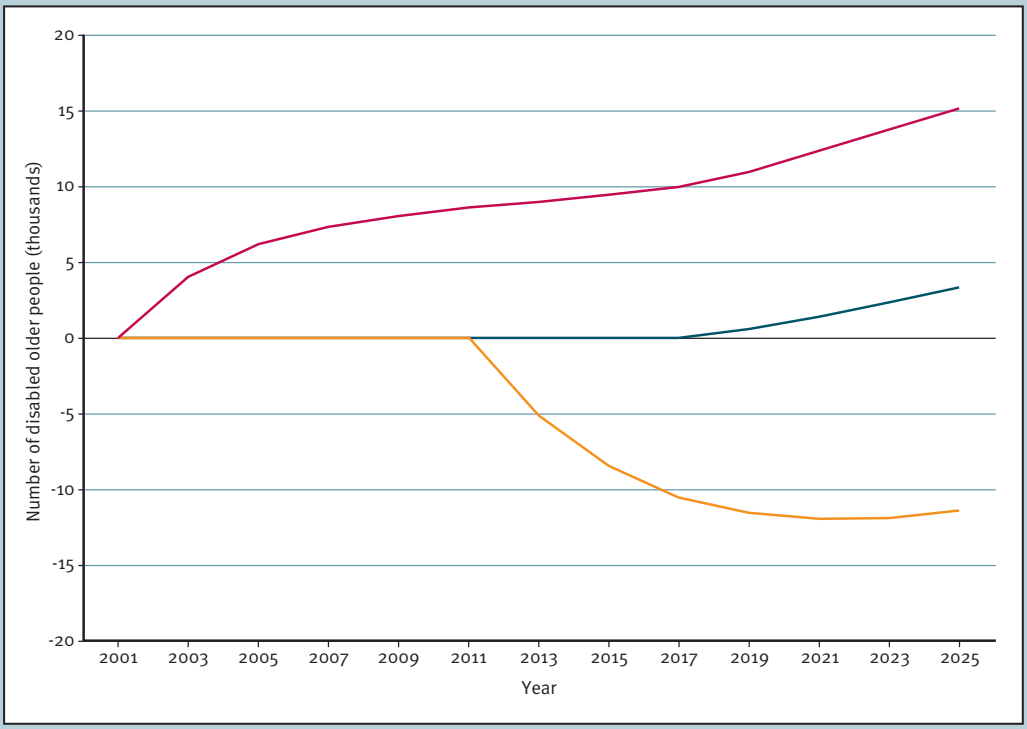


KEY

- Scenario 1: Transition rate to death decreased by 5% from 2015
- Scenario 2: Prevalence decreased by 2% every 2 years from 2011; transition rate to disability decreased by 10% from 2011 and to death decreased by 5% from 2015
- Scenario 3: Prevalence increased by 0.5% every 2 years from 2001; transition rate to disability increased by 10% from 2001 and to death increased by 5% from 2015

A decrease in the prevalence of stroke and CHD of 2 per cent and in the risk of becoming disabled of 10 per cent, as well as in the risk of dying of 5 per cent, would lead to a rise in the total population of 82,000 by 2025 (*see* Table 9 opposite). The disabled population would decrease by 11,500 by 2025, over and above that caused by the ageing of the population (*see* Table 9 opposite and Figure 10 overleaf).

10 **CHANGE IN NUMBERS OF DISABLED OLDER PEOPLE UNDER SCENARIOS OF DIFFERING STROKE AND CORONARY HEART DISEASE TRENDS COMPARED WITH THE NO-CHANGE SCENARIO (AGEING OF POPULATION ONLY), 2001 TO 2025**



KEY

- Scenario 1: Transition rate to death decreased by 5% from 2015
- Scenario 2: Prevalence decreased by 2% every 2 years from 2011; transition rate to disability decreased by 10% from 2011 and to death decreased by 5% from 2015
- Scenario 3: Prevalence increased by 0.5% every 2 years from 2001; transition rate to disability increased by 10% from 2001 and to death increased by 5% from 2015

If the prevalence of stroke and CHD increases along with their disabling consequences and the case fatality decreases, the total older population will increase by 10,000 over and above the increases caused by population ageing (*see* Table 10, p 28 and Figure 9 opposite). The dependent population would rise by 15,000, leading to a small increase in the proportion with disability (*see* Table 10 and Figure 9).

Conclusions and recommendations

Conclusions

In this report we have explored the effect of different overall health scenarios on the future numbers of older people with disability at a level needing significant care (unable to put on shoes or socks, bath or have an all-over wash, or get in and out of bed). These projections are based on the individual experiences of a nationally representative sample of people aged 65 years and over as they experience and report disease and subsequent disability.

Ageing of the population alone, with no alteration in the prevalence of diseases or the age-specific rates of becoming disabled or recovering, will result in a 67 per cent increase in the numbers with disability over the next 20 years. Numbers of the oldest old (those aged 85 years and over) with disability will double. In addition the proportion of the older population experiencing one of the key diseases considered – arthritis, coronary heart disease (CHD), stroke and dementia – will increase by over 40 per cent by 2025.

If the emphasis of public health interventions and medical treatments continues to be on extending life at older ages in those with disease, with little or no consideration for the quality of life in terms of alleviating or postponing the disabling consequences of disease, there will be a significant increase in the size of the disabled population and an expansion of disability. By 2025 we estimate that there will be around 50,000 extra older people with disability at a level needing long-term care, in addition to the rises caused by ageing of the population.

Moderate improvements in population health from reductions in levels of obesity and other negative health behaviours and intensive hypertension control could reduce the prevalence of arthritis, CHD, stroke and dementia. The impact of these, together with the emergence of new treatments or technologies focused on reducing the disabling consequences of disease, could considerably reduce the numbers with disability by 2025, with up to 80,000 fewer disabled older people. However, this will make only limited inroads into offsetting population ageing and there will still be an overall increase in the numbers of disabled older people by 57 per cent. Furthermore, any reduction of the disabling consequences of disease will result in further gains in life expectancy as mortality rates for non-disabled people are lower than those for disabled people. Thus, with the exception of stroke, the numbers of those with disease rises, because the overall reduction of prevalence by 2 per cent every 2 years is insufficient to counteract this increase. Hence a compression of disability is unlikely unless the level of severity of disability associated with these diseases diminishes.

Strengths and limitations

The Medical Research Council Cognitive Function and Ageing Study (MRC CFAS) is a nationally representative longitudinal study of a cohort of older people aged 65 years and over in 1991. The study included urban and rural areas and those living in institutions and is therefore representative of the total older population at the beginning of the 1990s. However, MRC CFAS includes very few older people from ethnic minorities and over the next 20 years these will form an increasing part of the older population as the large younger cohorts age. In the 2001 Census only 1 per cent of the older population was of Asian origin, whereas this rises to 3 per cent for the 40- to 64-year-old age group. We have not been able explicitly to model the impact of ageing of the ethnic minority populations because of a lack of data on disability transitions in this population, but the known greater prevalence of stroke, CHD and diabetes in the south Asian population, the largest ethnic minority population in the UK, suggests that our estimates may be conservative.

The majority of projection models have concentrated on a single disease and on its evolution. Incorporating different diseases with their varied impact on disability and mortality have enabled the investigation of the impact of treatments such as hypertension control that reduce mortality in stroke, CHD and vascular dementia, and of risk factors such as obesity that act concurrently on diseases. Indeed the Second Wanless Report highlighted obesity as a major public health threat (Wanless 2002).

Although the diseases considered in the transition model were ascertained from self-report, the majority were self-reports of doctor-diagnosed morbidity. Moreover, the prevalence of the main diseases in women aged 70 years and over in MRC CFAS is commensurate with other British studies, specifically the British Women's Heart and Health Study (Adamson *et al* 2004). The choice of diseases for the transition model was limited by the study and notably cancer was omitted. However, cancer has consistently been shown to have the most impact on mortality and little on disability (Mathers 1999). Limited allowance is made for reductions in mortality from cancer (and other diseases not included in our model) by the year-on-year gains in survival through the Government Actuary's Department (GAD) adjustments.

Previous projections of the number of older people with disability have relied on cross-sectional data to estimate the prevalence of disability, with assumptions that the age-specific prevalence of disability will remain constant over time. Prevalence is a function of both incidence and duration and therefore may remain constant because incidence and duration are changing relative to each other. Our projections, on the other hand, use the incidence of disability and we make the more realistic assumption that age-specific incidence rates have remained constant from 1991 until 2001.

Although the temporal relationship between disease and disability is as required, with disease preceding disability, the specific cause of the subsequent disability was not ascertained at interview with the older person. Thus the disease–disability link is not empirically established in our model.

Comparisons with other countries

Comparable projections for the USA deduced that a reduction in the prevalence of arthritis would have the greatest impact on the prevalence of functional limitations in the older

population, although the numbers saved from disease would be only a small fraction of the large population of disabled older people resulting from the ageing of the baby boomers (Boult *et al* 1994). However, the Boult model was based on self-report of all diseases, including memory problems, and only simulated a scenario where prevalence of each disease was increased by 1 per cent per year. Our findings from SIMPOP are based on a much greater study size, with objectively measured cognitive impairment and evidence-based scenarios.

Our findings that continued reductions in mortality at older ages will result in more years with disability, and potentially greater health care costs, confirm others (Bonneux *et al* 1998; Wagener *et al* 2001). In addition, projection models of future numbers with specific diseases such as dementia (Brookmeyer *et al* 1998) implicitly echo our findings that the ageing of the population will result in substantial rises in the numbers of older people with disability who need social care.

Evidence for reductions in the levels of disability in the older population worldwide are varied. Studies from the USA now show clear decreases in the prevalence of disability over a 20-year period from the beginning of the 1980s, with a more rapid decline in the last decade. The reasons for this remain unclear, with possible contributors being higher levels of education, improved medical treatments and greater use of assistive technology that allows older people to remain independent (Freedman *et al* 2004). Over a similar time period the prevalence of severe disability of Spanish older people reduced by over 3 per cent per year and the disability-free life expectancy (DFLE) increased, although in women the prevalence of self-care disability increased slightly (Sagardui-Villamor *et al* 2005). However, more recently in Sweden the prevalence of objectively measured function (physical capacity, lung function and cognition) and self-reported diseases increased between two cohorts who were aged 77 years and over in 1992 and 2002, and this was not an artefact resulting from omission of those in institutions or a change in reporting or expectations (Parker *et al* 2005). Sweden's life expectancy at birth of 82 years is two years greater than that of the USA or the UK and one year less than that of Spain. This demonstrates the variability that exists worldwide on the relationship between longer and healthier life.

Despite the reports of reductions in disability prevalence, the evidence for how to delay onset and progression is scant. Our work makes the important link between disease and disability, suggesting the effect that public health measures for promoting healthy lifestyles, particularly reducing obesity, might have. Reducing levels of obesity will have little effect on mortality rates but will have significant impact on disability (Reynolds *et al* 2005), with obesity in adulthood being associated with double the risk of activities of daily living (ADL) limitation at older ages (Peeters *et al* 2004) and showing a greater contribution to cases of arthritis in more recent years (Leveille *et al* 2005). Modest reductions in major cardiovascular risk factors appear more effective in terms of life-years gained than cardiological treatments (Unal *et al* 2005), but we need to know whether this is also true for disability-free life-years.

Recommendations

The planning of preventive, primary and secondary health, social and long-term care services for older people requires accurate projections of future need based on reliable estimates of the prevalence and incidence of cognitive and functional impairment. Future

planning will also require an understanding of the impact of chronic disease on function, the risk factors for impaired cognition and function, and the changing nature of informal care and social support, as well as the organisation of formal health, social and long-term care services, their cost-effectiveness, and the impact of increasing diversity in the older population resulting from ethnic and generational group differences.

Projections of the numbers and characteristics of the older population directly benefits health, care and pension providers, and the government, as well as older people themselves. At present we are limited through a lack of available data on the extent to which we can incorporate all the likely factors that affect and are affected by increasing dependency with age. Projections are also limited by the lack of data to inform realistic future scenarios. Future routine data for public health are unlikely to provide sufficient data on disability, which necessitates specific dedicated studies for estimating health and social care costs.

Projection models that link disease and disability in the manner explored here enable evidence to be gathered about the potential of treatment and prevention strategies to reduce the disability burden in the future. It was evident from our thorough and systematic review of the literature in two of the diseases – stroke and CHD – that the efficacy of treatments and interventions is mostly assessed in terms of their ability to delay death or a combination of death and dependency, rather than disability alone. In the other two diseases – arthritis and dementia – where saving lives is a lesser issue, outcomes were generally disease-specific measures such as cognitive function scores or physiological measures. Knowledge of how treatments in these areas improve the ability to function in daily life activities through the inclusion of these as secondary outcomes would potentially benefit older people and their families as well as policy-makers.

Improved treatment and diagnosis will have led to improvements in the health of future older people, but there are other cohort effects that may result in improvements of similar magnitude. New cohorts have had the benefit of greater education and better conditions and nutrition during early life, all of which are known to affect health later in life. It is important to understand whether socioeconomic differences in the onset of disability are simply a manifestation of greater disease burden in those with lower socioeconomic status. However, the true picture of the trends in the health of the UK older population has been limited by geographical area (Spiers *et al* 1996) or by exclusion of those in institutional care (Jarvis 1998). There is only a handful of purposefully designed longitudinal studies of ageing that have been conducted within the UK, with only the recent English Longitudinal Study of Ageing (ELSA) and MRC CFAS being nationally representative. The 15 years that have now elapsed since the MRC CFAS would provide an ideal opportunity to compare sufficiently different cohorts, but using a large enough sample to compare down to the level of less prevalent diseases.

Other groups in which substantial cohort differences may be expected are ageing ethnic minority populations from Commonwealth countries who migrated to the UK between 1946 and 1965. Individuals in these cohorts are now reaching retirement age and have had very different life histories and experiences to those expected for subsequent generations. There is evidence of differences in the prevalence of disease and functioning between different ethnic groups, but little or none on incidence, and it is unclear whether the health experience of older people from ethnic minority groups is the result of genetic differences

or risk factors associated with lifestyle, income and environmental or social deprivation (Nazroo 1998). The health and morbidity patterns of successive generations of ethnic minority cohorts could be expected to converge with patterns experienced by the majority population in the future as differences in socioeconomic status and wealth narrow. The rate of convergence, however, is not known and therefore baseline data are essential if these differences are to be investigated in the future. It is essential that such a study includes objective measures of performance to tease out potential differences in self-rated disability between ethnic groups and those in institutions, given the variation in institutionalisation rates between different ethnic groups in the UK.

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