The effect of dementia trends and treatments on longevity and disability over the next 20 years

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Abstract

The numbers of people with dementia are projected to double between 2001 and 2040, in line with continued increases in life expectancy. Projections have failed to account for how changing risk factors might impact on future numbers with dementia or disability. We use a dynamic macro-simulation projection model to calculate the numbers of older people with and without disability to 2026 and explore the impact of dementia treatments to delay onset and functional loss. Transition rates to disability and death conditional on a range of conditions, calculated from MRC CFAS data, were applied to the 1992 E&W population. Ageing of the population alone resulted in 44% more older people between 2006 and 2026 and 86% more with disability. A combination of reduced incidence and disabling consequences alongside improved survival provided the largest reductions in the disabled population (18,000) and numbers cognitively impaired (308,000) compared with ageing of the population alone.

Introduction

One of the consequences of increasing life expectancy is an increase in age-related diseases such as dementia. An international review(2) has estimated that the number of people with dementia worldwide will rise from 24·3 million currently to 42·3 million by 2020 and 81·1 million by 2040. Developed societies such as the UK start from a higher prevalence, and numbers of people with dementia are projected to double between 2001 and 2040;(2) the implications for future need for health and social care are serious. Failing cognitive function results in an increasing inability to self-care, and dementia is one of the major causes of disability in later life.(4) Cognitive impairment is present in over a third of disabled older people aged 65 years and over(5) whilst the majority of the very elderly (aged 85 years and over) with dementia are dependent in basic activities of daily living.(6) Since the need for health and social care of older people is determined primarily by disability,(6) service planning for this group requires projections based on reliable estimates of the prevalence and incidence of disability.

To date, most projections of numbers with dementia have been based on population demography and epidemiological estimates of dementia prevalence. In the United States, (US), Brookmeyer *et al.*(1) have examined the impact of delaying disease onset on the growth in numbers of those with Alzheimer's disease (AD), and Sloane *et al.*(12) have modelled the effect of hypothetical new interventions based on experience with other disorders (cardiac failure, Parkinson's disease). However, these studies focused on AD only and did not take into account both the effect of changing risk factors for dementia and the impact of existing and potential therapeutic strategies. Other simulation models of population health do exist, but these have considered consequences of changing risk factors and/or treatments on mortality only.(14, 15) No previous modelling exercise has studied the full spectrum of dementia, or considered disability as a major consequence of declining cognitive function.

This study reports the results of a simulation model comparing future numbers of older people with disability and disability-free life expectancy (DFLE) over the next 20 years from ageing of the population alone with those from four evidence-based dementia scenarios of: i) reductions in incidence, ii) improved survival, iii) reduction in disability, and iv) optimal risk factor control combining all three scenarios.

Methods

Data

The disability and disease data underlying SIMPOP come from the MRC Cognitive Function and Ageing Study(16), a nationally representative longitudinal study of those aged 65 years and over which began in 1991 and includes both community-dwelling and institutionalised subjects. Full details of SIMPOP have already been reported (17) so only a brief description is included here.

Disability was defined as participants' inability to put on shoes and socks, have a bath or all-over wash, or inability to transfer to and from bed, this level of severity chosen to be parsimonious with a model of long-term care needs and costs(18). Chronic conditions included in the model were generally self-reported: heart attack, treated diabetes, asthma, chronic bronchitis, arthritis, Parkinson's disease, treated hypertension, stroke diagnosed by a doctor, hearing problems, eyesight problems, emotional problems and under-active thyroid. Diagnostic scales were used for angina and peripheral vascular disease(19) and cognitive impairment (CI) (Mini-Mental State Examination score 0- 21: moderate or severe; 22-25 mild) (20). We defined coronary heart disease (CHD) as heart attack and/or angina.

Simulation model, SIMPOP

Two-year transition probabilities conditional on disease and sociodemographic and lifestyle factors (education, social class, living arrangements, smoking status) were derived from a trichotomous logistic regression and then applied to the 1992 mid-year England and Wales revised population estimates for those aged 65 years and over by two-year age band, to produce sub-populations disabled and non-disabled aged 67 years and over two years later. The 65-66 year age group were replenished from national population estimates. Estimates of the prevalence of CHD, stroke, arthritis, diabetes and Parkinson's disease in 2006 from SIMPOP were compared to the Health Survey for England (HSE) 2005 (21) and were found to be close, apart from diabetes. For all scenarios therefore we increased the prevalence of diabetes in SIMPOP to national values (17).

Life expectancy was calculated from abridged life tables with the deaths and population counts in two year age bands. Probabilities of death were smoothed by fitting logit models and then extrapolated to produce life tables closed at age 99. Disability-free life expectancy (DFLE) was calculated by the Sullivan method (22) by applying the age-specific prevalence of disability to the life table.

Dementia scenarios

Within SIMPOP there were three parameters for each disease that could be manipulated to mimic future changes: the disease prevalence and the probabilities of death and disability within two years conditional on the disease. To inform the magnitude of change, literature on dementia in both those currently aged 65 years and over and in those who would be 65+ by 2026, was systematically reviewed for evidence on: trends and risk factors; disease-specific disability; preventive strategies and treatments and their efficacy, cost-effectiveness and diffusion(18). The review found no evidence for changing incidence of dementia other than might occur through cerebrovascular risk factors and treatment. Most of the literature on the effect of interventions reported change in cognition without good data on the impact on disability, except that cholinesterase inhibitors (CEIs) may reduce disease-specific disability (7).

Given the paucity of data on the impact of interventions on disability we assumed a change of 5% in either the transition probabilities to onset of disability or to death to represent a small impact, and 10% a moderate one. The main scenarios (Box 1) were built around assumptions of future reductions in incidence, improvements in survival with dementia, and reductions in disability consequent to dementia through new and existing treatments.

Results

Disability in the baseline population in 1991-2 ranged from 3·7% at 65 to 66 years to 58·7% at 91 years and over.

Size of the older population aged 65+

Population ageing alone resulted in a 39% increase in the older population between 2006 and 2026 (Table 1). Compared to population ageing alone, further increases in the size of the population aged 65+ years would result from all scenarios considered (Table 1), including reduced dementia incidence, since mortality is lower in those without cognitive impairment. The combined scenario produces the largest increase between 2006 and 2026 of 40.6%.

Numbers with disability

Population ageing alone resulted in an 82% increase in the numbers with disability between 2006 and 2026 (Table 1). Decreases in the disabled older population from population ageing alone result from all but the improved survival scenario with the combined scenario producing the greatest decrease (15,000) from population ageing by 2026. In contrast, increasing survival of those with dementia leads to an increase in the disabled population of 4,400 over population ageing alone.

Numbers with dementia

Population ageing alone results in a 63% increase between 2006 and 2026 in the numbers of older people with dementia, from 0.8 million to 1.3 million (Table 1) and all other scenarios result in very similar increases. Though increases in the total and disabled populations were similar in the earlier (2006 to 2016) and the later period (2016 to 2026), increases in the numbers with dementia were higher in the later period than the earlier.

Life expectancy and disability-free life expectancy

Under population ageing alone life expectancy (LE) over the period increased by 2.6 years at age 65 and 1.7 years at age 85 (Tables 2 and 3). These will be accompanied by gains in disability-free life expectancy (DFLE), though by fewer years than LE, resulting in more years spent with disability (DLE), a decrease in the proportion of remaining life spent free of disability (5% at age 65 and 11% at age 85 between 2006 and 2026) and an expansion of disability. Indeed all the dementia scenarios resulted in an expansion of disability at age 65 and at age 85 and by age 85 the proportion of life spent free of disability had decreased by 11% between 2006 and 2026 compared to 4.5% at age 65. At both ages there appeared to be around 1.5 years in 2006 and around 3 years by 2026 spent with disability, consistently across all scenarios.

Discussion

This dynamic macro-simulation model shows that population ageing alone will result in a 39 per cent increase in the numbers aged 65+ years over the next 20 years, with 500,000 more older people with moderate and severe cognitive impairment and over 700,000 more with disability. The largest contribution will be in the population aged 85+ years whose numbers will increase by 60 per cent. Life expectancy at age 65 will increase by 14% with 1.5 years extra disability free and 1.1 years extra with disability. Since the proportion of remaining life spent free of disability will reduce and expansion of disability is evident over the next 20 years.

The greatest reduction in the disabled population from population ageing alone, amounting to 15,000, was from delayed onset, reduced disability and improved survival, achievable through optimal control of vascular risk factors. However this represents only a 1% reduction in the size of the disabled population. Offsetting the impact of an ageing population will require larger prevention and treatment effects than are currently achievable. Moreover all the scenarios resulted in an expansion of disability.

Our scenario of reduced incidence by delayed progression from mild to moderate/severe cognitive impairment, reduced the numbers of older people with dementia relative to population ageing alone. However delaying progression would still produce an overall gain in the numbers with dementia of 37% between 2006 and 2026. Another model showed an overall reduction of 10% in numbers with moderate/severe Alzheimer's disease (AD) but a 47% increase in mild over the same period through delayed onset and slower progression (12), although mortality rates were not based on observed data and transitions from mild to moderate/severe dementia were assumed to more than halve.

Evidence for reductions in the levels of disability in the older population worldwide are varied(23, 24). Decreases in disability prevalence averaging 1-2% per year have been observed in the US in the last twenty years, with a more rapid decline in the last decade(25), though this is alongside increasing disability severity levels(26) and increases in chronic disease(27). Reasons for declines in prevalence 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(25, 28). Over a similar time period even greater annual decreases of over 3% have been reported in Spain, though in women the prevalence of self-care disability increased slightly(29). In contrast, comparison of two Swedish cohorts aged 77 years and over in 1992 and 2002 showed increases in the prevalence of objectively measured function (physical capacity, lung function and cognition) and self-reported diseases increased and this was not an artefact due to omission of those in institutions or a change in reporting or expectations(30). Sweden's life expectancy at birth of 82 years is 2 years greater than that of the US or UK and one year less than

Spain, demonstrating the variability that exists worldwide on the relationship between longer and healthier life.

Our projections are based on the individual experiences of people aged 65 years and over as they experience and report disease and subsequent disability. MRC CFAS, which provided the transition rates to and from disability and to death, included urban and rural areas and those living in institutions and is therefore representative of the total older UK population at the beginning of the 1990s. However limitations of our model concern the underlying data. Our disability definition equated to requiring long-term care with a prevalence of 8% in those aged 65+ in 1992 compared to 34% in the oldest old aged 85+. Few people from ethnic minorities contributed to MRC CFAS, and these will form an increasing part of the older population over the next 20 years; in the 2001 Census fewer than 3 per cent of the older population were non-white, compared with 9 per cent for the 40-44 year-old age group. We did not model the impact of ageing of ethnic minority populations because of a lack of data on disability transitions. Nevertheless, the known greater prevalence of stroke, CHD and diabetes in the south Asian population, the largest ethnic minority in the UK, suggests that our estimates may be conservative.

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 incidence, duration and recovery and therefore may remain constant because these are changing relative to each other. Indeed ,Wolf(26) found improving trends in disability onset accompanied by downward trends in recovery which overall produced favourable trends in prevalence of disability. However, despite the reports of reductions in disability prevalence, the evidence for how to delay onset and progression is scant. Our projections use incidence, recovery and mortality rates explicitly and make the important link between disease and disability suggesting the potential effect of public health measures for promoting healthy lifestyles as well as the effect of current and emerging treatments.

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Box 1: Dementia scenarios modelled in SIMPOP

Population ageing
The age-specific prevalence of diseases, incidence of and recovery rates to dependency all remain at 2006 levels and mortality rates continue to decline at levels commensurate with GAD principal projections.

Reduced incidence
Reduced incidence of dementia of 10% from 2012, to reflect assumptions of delayed onset (1) or better control of hypertension (3), estimated by reducing dementia prevalence by 2% cumulatively every two years from 2012 for mild cognitive impairment and from 2016 for moderate or severe.

Improved survival
Improved survival with dementia consequent upon control of vascular risk factors in those with mild cognitive impairment. As mortality already reduces commensurate with GAD projections, we assume only a small further reduction of 5% in those with mild dementia from 2012.

Reduced disability
Reduced disability with dementia in line with evidence that CEIs could delay the time to functional decline by six months to one year (7, 8). CEIs are presently recommended only for patients with a MMSE score 10 to 20 (http://www.nice.org.uk), and this was included in the model as a 10% reduction in transitions to disability for moderate or worse cognitive impairment only, although observational evidence of efficacy in patients with mild cognitive impairment exists (9). However uptake of CEIs in those who might potentially benefit is low (10). To explore the effect of greater uptake we assumed a 5% reduction in the transitions to disability from 2010 in mild and a 10% reduction in moderate or severe cognitive impairment.

Optimal control of vascular risk factors
Combined scenario in keeping with optimal control of vascular risk factors (11) (13).

Table 1: Simulated total and disabled populations (thousands) aged 65+ for population ageing alone and dementia scenarios

	2006	2010	2016	2020	2026	% change 2006 to 2016	% change 2016 to 2026	% change 2006 to 2026
Ageing of the population								
Total population	8855	9305	10497	11108	12335	18.5	17.5	39.3
Disabled population (%)	855 (9.7)	952 (10.2)	1145 (10.9)	1282 (11.5)	1555 (12.6)	34.0	35.8	81.9
With dementia CI (%)	812 (9.2)	878 (9.4)	1002 (9.5)	1104 (9.9)	1325 (10.7)	23.4	32.3	63.3
Reduced incidence								
Total population	8855	9305	10503	11134	12418	18.6	18.2	40.2
Disabled population (%)	855 (9.7)	952 (10.2)	1143 (10.9)	1276 (11.5)	1546 (12.4)	33.7	35.2	80.8
With dementia CI (%)	812 (9.2)	878 (9.4)	1002 (9.5)	1106 (9.9)	1334 (10.7)	23.4	33.2	64.4
Improved survival								
Total population	8855	9305	10507	11125	12361	18.6	17.6	39.6
Disabled population (%)	855 (9.7)	952 (10.2)	1146 (10.9)	1284 (11.5)	1559 (12.6)	34.0	36.1	82.4
With dementia CI (%)	812 (9.2)	878 (9.4)	1003 (9.5)	1108 (10)	1331 (10.8)	23.6	32.6	64.0
Reduced disability								
Total population	8855	9305	10501	11114	12343	18.6	17.5	39.4
Disabled population (%)	855 (9.7)	952 (10.2)	1139 (10.8)	1276 (11.5)	1547 (12.5)	33.3	35.9	81.0
With dementia CI (%)	812 (9.2)	878 (9.4)	1000 (9.5)	1103 (9.9)	1324 (10.7)	23.2	32.4	63.1
Optimal control of vascular factors								
Total population	8855	9305	10517	11158	12453	18.8	18.4	40.6
Disabled population (%)	855 (9.7)	952 (10.2)	1134 (10.8)	1268 (11.4)	1539 (12.4)	32.7	35.7	80.1
With dementia CI (%)	812 (9.2)	878 (9.4)	1000 (9.5)	1106 (9.9)	1337 (10.7)	23.2	33.7	64.7

Table 2: Simulated life expectancy (LE), disability-free life expectancy (DFLE), life expectancy with disability (DLE) and proportion of life spent disability-free (DFLE/LE) at age 65 for population ageing alone and dementia scenarios

	2006	2010	2016	2020	2026	% change 2006 to 2016	% change 2016 to 2026	% change 2006 to 2026
Ageing of the population								
LE (years)	18.1	18.6	19.5	20.1	20.7	7.6	6.0	14.3
DFLE (years)	16.4	16.7	17.2	17.6	17.9	5.0	3.8	9.0
DLE (years)	1.8	1.9	2.3	2.6	2.9	32.5	21.3	63.9
DFLE/LE (%)	90.3	89.5	88.1	87.2	86.1	-2.5	-2.2	-4.6
Reduced incidence								
LE (years)	18.1	18.6	19.6	20.3	21.1	8.1	7.2	16.2
DFLE (years)	16.4	16.7	17.3	17.7	18.2	5.4	5.0	10.8
DLE (years)	1.8	1.9	2.3	2.6	2.9	33.3	22.1	66.1
DFLE/LE (%)	90.3	89.5	88.1	87.2	86.2	-2.5	-2.2	-4.6
Improved survival								
LE (years)	18.1	18.6	19.6	20.2	20.8	7.9	6.0	14.6
DFLE (years)	16.4	16.7	17.3	17.6	17.9	5.2	3.8	9.3
DLE (years)	1.8	1.9	2.3	2.6	2.9	33.1	21.4	64.6
DFLE/LE (%)	90.3	89.5	88.1	87.2	86.1	-2.5	-2.2	-4.7
Reduced disability								
LE (years)	18.1	18.6	19.5	20.2	20.8	7.7	6.0	14.4
DFLE (years)	16.4	16.7	17.2	17.6	17.9	5.1	3.8	9.2
DLE (years)	1.8	1.9	2.3	2.6	2.9	31.8	21.3	63.0
DFLE/LE (%)	90.3	89.5	88.2	87.3	86.2	-2.4	-2.2	-4.5
Optimal control of vascular factors								
LE (years)	18.1	18.6	19.7	20.4	21.2	8.5	7.2	16.6
DFLE (years)	16.4	16.7	17.4	17.8	18.3	5.9	5.0	11.4
DLE (years)	1.8	1.9	2.3	2.6	2.9	32.8	22.1	65.4
DFLE/LE (%)	90.3	89.5	88.2	87.3	86.3	-2.4	-2.2	-4.5

Table 3: Simulated life expectancy (LE), disability-free life expectancy (DFLE), life expectancy with disability (DLE) and proportion of life spent disability-free (DFLE/LE) at age 85 for population ageing alone and dementia scenarios

	2006	2010	2016	2020	2026	% change 2006 to 2016	% change 2016 to 2026	% change 2006 to 2026
Ageing of the population								
LE (years)	5.7	6.0	6.5	7.0	7.4	13.6	12.7	29.0
DFLE (years)	4.2	4.3	4.5	4.7	4.8	7.6	5.9	14.3
DLE (years)	1.5	1.7	2.0	2.3	2.6	30.2	26.7	69.6
DFLE/LE (%)	73.3	72.2	69.5	67.6	65.0	-5.3	-6.7	-11.4
Reduced incidence								
LE (years)	5.7	6.0	6.6	7.1	7.7	14.6	15.3	33.6
DFLE (years)	4.2	4.3	4.6	4.8	5.1	8.7	9.9	20.1
DLE (years)	1.5	1.7	2.0	2.3	2.6	30.9	26.8	70.7
DFLE/LE (%)	73.3	72.2	69.6	68.0	65.9	-5.1	-5.3	-10.1
Improved survival								
LE (years)	5.7	6.0	6.6	7.0	7.4	14.2	12.7	29.7
DFLE (years)	4.2	4.3	4.6	4.8	4.8	8.2	6.0	15.0
DLE (years)	1.5	1.7	2.0	2.3	2.6	30.5	26.7	70.1
DFLE/LE (%)	73.3	72.2	69.5	67.7	65.0	-5.2	-6.6	-11.3
Reduced disability								
LE (years)	5.7	6.0	6.5	7.0	7.4	13.9	12.6	29.3
DFLE (years)	4.2	4.3	4.6	4.8	4.9	8.4	6.0	15.2
DLE (years)	1.5	1.7	2.0	2.2	2.6	28.9	26.7	68.0
DFLE/LE (%)	73.3	72.2	69.8	68.0	65.4	-4.8	-6.6	-10.9
Optimal control of vascular factors								
LE (years)	5.7	6.0	6.6	7.2	7.7	15.5	15.2	34.6
DFLE (years)	4.2	4.3	4.7	4.9	5.1	10.4	9.9	22.1
DLE (years)	1.5	1.7	2.0	2.3	2.6	29.5	26.8	69.0
DFLE/LE (%)	73.3	72.2	70.1	68.6	66.5	-4.4	-5.2	-9.3