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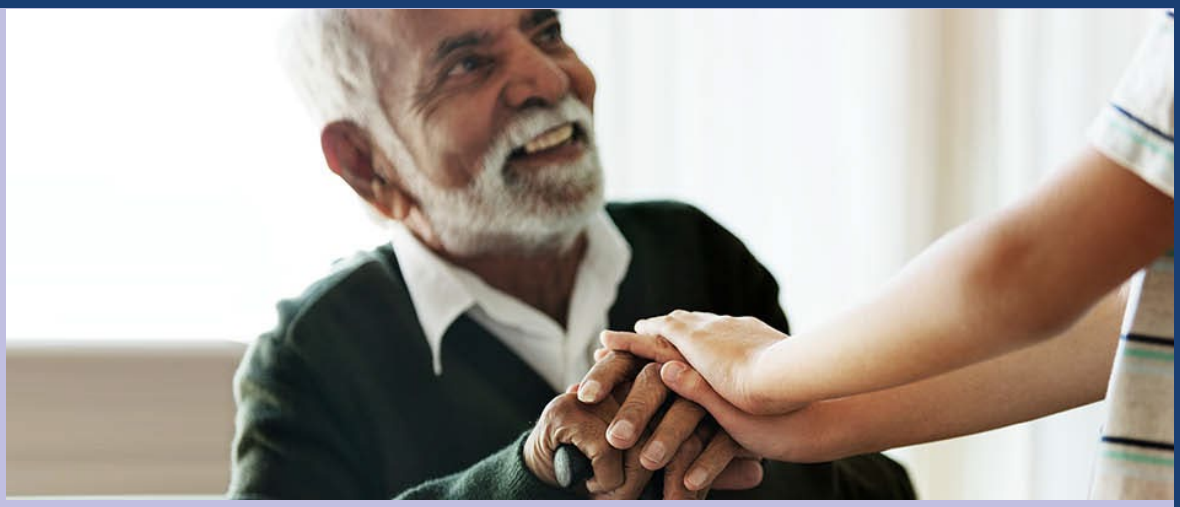

The contribution of single and multiple chronic conditions to the deteriorating time trends in later-life disability

Part 1: Incidence, recovery or longer survival?

Holly Bennett, Fiona Matthews, Andrew Kingston, Neil Pendleton, Martin Knapp, Carol Jagger

Report

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Part 1: Incidence, recovery or longer survival?

Report

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Contents

Executive Summary 1
Findings 1
Conclusion 2
Background 3
Methods 3
Data 3
Measures 3
Statistical analysis 4
Results 5
Demographics 5
Disability-free Life Expectancy 6
Probability of transitioning between disability states and death over time 8
Dependency free life expectancy 10
Probability of transitioning between dependency states and death over time 12
Comparison of cross-sectional and longitudinal estimates 14
Discussion 15
Main findings 15
Strengths and Limitations 15
Comparison between cross-sectional and longitudinal results 16
Conclusion 16
References 17
Appendix 19
Methods 19
Statistical analysis 19
Results 23
Sensitivity analyses 27

Executive Summary

In recent decades gains in life expectancy have left women living longer with mild disability and low-level dependency. Our understanding of these changes has come from different studies that collect data at a single point in time. This report adds valuable new information from analyses of the Cognitive Function and Ageing Studies (CFAS I and II), both of which collected information from participants at multiple time points, with CFAS I beginning in 1991 and CFAS II in 2011. The analyses presented here address the question of whether people are living extra years with disability and dependency because a) more people are becoming disabled or dependent, b) people are surviving longer with disability and dependence or c) because when people develop disability or dependence, they are less likely to recover.

Findings

MEN: Changes in years lived with disability and dependence, over the period between CFAS I and CFAS II (approximately 1991 to 2011).

Disability

- Men aged 65 years
    - Gained on average 3.7 years of life disability-free, 0.8 years with disability
    - Could expect to live around 75% of their remaining years without disability in both studies
- Gains in years disability-free and with disability over time resulted from
    - Lower risk of becoming disabled
    - Lower risk of death from both disability-free and disabled states
    - No change in risk of recovery from disability
- The age at which men could expect to have an equal number of remaining years without disability or with disability rose from 79 years in CFAS I to 82 years in CFAS II.

Dependency

- Men aged 65 years
    - Gained on average 3.5 years of life independent and 1.1 years dependent
    - Could expect to live around 70% of their remaining years independent in both studies
- Gains in years independent and dependent over time resulted from
    - Lower risk of becoming dependent
    - Lower risk of death from both independent and dependent states.
    - No change in risk of recovery from dependency
- The age at which men could expect to have an equal number of remaining years of life independent and dependent rose from age 75 in CFAS I to age 79 in CFAS II.

WOMEN: Changes in years lived with disability and dependence, over the period between CFAS I and CFAS II (approximately 1991 to 2011).

Disability

- Women aged 65 years
  - Gained on average 2.0 years of life disability-free, 0.1 years with disability
  - Could expect to live 60% of their remaining years without disability in CFAS II, a rise from 56% in CFAS I
- Gains in years disability-free and with disability resulted from
  - Lower risks of becoming disabled
  - No change in risk of death from either non-disabled and disabled states
  - No change in risk of recovery from disability
- The age at which women could expect to have an equal number of years without disability and with disability rose from age 68 in CFAS I to age 71 in CFAS II.

Dependency

- Women aged 65 years
  - Gained on average 2.5 years of life independent and had 0.6 fewer years dependent
  - Could expect to live 54% of their remaining years independent in CFAS II, a rise from 45% in CFAS I
- Gains in years independent and dependent resulted from
  - Lower risk of becoming dependent
  - Lower risk of death from both dependent and independent states.
  - No change in risk of recovery from dependence
- The age at which women could expect to have an equal number of remaining years of life independent or dependent rose from before age 65 years in CFAS I to 67 years in CFAS II.

Conclusion

This report highlights three important points:

1. Recent gains in disability-free and dependency-free life years from age 65 appear to be due to lower probabilities of becoming disabled or dependent for men and women, and lower probabilities of death from non-disabled or independent states for men.
2. Although the prevalence of disability and dependency increased between 1991 and 2011, these prevalences are likely to stabilise due to the greater decrease in incidence of disability/dependency than the increase in survival.
3. Women are experiencing more disability and dependency. Women spend more years with disability or dependency than men, and reach the age where they can expect an equal number of remaining years with and without disability, some 10 years earlier than men.

These analyses provide the basis for future analyses which will take into account disability and dependency severity and how changes in health conditions over time contribute to trends in disability-free and dependency-free life expectancy. Our analyses show the importance of

delaying the onset of disability and dependency, particularly in women, so that a greater proportion of their remaining life is independent and free of disability.

Background

Disability and dependency are feared by many older people, and place increasing demands on families, services and society. An understanding of the trends in, and drivers of, late life disability and dependency are essential to inform future healthy ageing policies. Existing evidence from cross-sectional analyses suggests that the extra years of life gained over the last two decades are likely to be free of cognitive impairment, but that women are living longer with mild disability and low-level dependency [2, 3]. This project uses longitudinal data from the Cognitive Function and Ageing Studies (CFAS I and II) to explore trends over time in years lived with and without disability and dependency in more depth. The findings here represent the first report from an ongoing study that is also examining the influence of single and multiple long-term conditions, and years with different levels of severity of disability and dependency.

The aim of this study is to investigate whether the extra years of life gained with disability/dependency are due to:

a) increased incidence of disability/dependency
b) reduced ability to recover from disability or return to independence, or
c) longer survival with disability/dependency

Methods

Data

The Cognitive Function and Ageing Studies (CFAS I and CFAS II) are population based studies randomly sampled from Primary Care Trusts (previously Family Health Service Authority lists) in three centres – Cambridgeshire, Newcastle and Nottingham. The sampling process was identical in both studies, allowing temporal comparisons to be made. In CFAS I 7635 participants took part at baseline with interviews beginning in 1991 and for CFAS II 7762 individuals participated in baseline interviews, beginning in 2008. To ensure the full range of the older population was encompassed by the sampling process, the sampling frame included care homes, nursing homes and semi-dependent housing. Those aged 75 years and over were oversampled in both studies. For a weighted subsample of participants, informant interviews were requested, these being conducted with a friend, family member or carer nominated by the participant. Crucially for participants who were cognitively frail, informants were able to offer an alternate source of information. Both CFAS I and II had follow-up interviews at two years. Further details of these are provided online [4] and in the Appendix.

Measures

Disability was measured as impairment in ordinary or instrumental activities of daily living (ADL and IADL [5]) and was split into no disability, mild to moderate disability and severe disability as previously [2, 6] (see Box 1 for definition of categories).

Dependency was assessed using Isaacs and Neville's interval measure [7] to classify individuals into four categories; independent, low dependency, medium dependency and high dependency. Those with high dependency required 24 hour care, either because their care needs were unpredictable or care was needed constantly. Medium dependency was defined as requiring care at regular times each day and low dependency as needing help less than daily. Measures used for each of the dependency levels are given in Box 1. In the CFAS I two-year follow-up, items on toileting and light housework were omitted and replacement items were sought that were close in the hierarchy of ADL [8], the effect of this on the prevalence of dependency being examined in a sensitivity analysis described in the Appendix.

Box 1: Classification of disability and dependency

Disability

Severe disability (ADL and IADL impairment)

Was housebound or required help with at least one of the following: washing all over, preparing and cooking a hot meal, putting on shoes and socks.

Mild/moderate disability (IADL impairment)

Needed help with heavy housework or shopping and carrying heavy bags.

No disability

Did not need help with any of the above and could get around outside the house.

Dependency

High dependency

Either needed help with toileting or feeding, was chair or bedbound or had severe cognitive impairment (score 0-9 on the Mini Mental State Examination [1]). In the two-year follow up combined screening and assessment interview in CFAS I incontinence replaced toileting.

Medium dependency

Needed help with either preparing and cooking a hot meal or putting on shoes and socks.

Low dependency

Required help with cutting their toenails, shopping, doing light or heavy housework or

Statistical analysis

For the longitudinal analyses here multistate models were fitted using Interpolated Markov Chain (IMaCh) software version 0.99r19 to estimate transitions between, for example, disability-free and disability states and death and the resulting total life expectancy and life expectancy with and without disability or dependency [9]. Disability and dependency progression and recovery were both modelled, making death the only absorbing state. Disability was grouped into no disability or any disability. Dependency was grouped into independent or any dependency. Further details of the modelling and weighting of the data to account for loss to follow-up are provided in the Appendix.

Results

Demographics

Of the 7635 participants at baseline in CFAS I, 60.8% were women (Appendix Table 2) and the average age at interview was 75.6 years. Before the two year follow up interview 819 (10.7%) of CFAS I baseline participants had died and 5156 (76%) of those alive (N=6816) agreed to be interviewed again, whilst 1660 either refused or had moved away. In CFAS II there were 7762 participants at baseline, of whom 56.1% were women (Appendix Table 2) and average age was slightly older at 76.4 years. Of the 7119 participants who were still alive when approached for a two-year follow up interview, 5288 (74%) agreed, a similar proportion to CFAS I, whilst 1831 refused or moved away and 643 (8.3% of baseline participants) had died before being approached for the second interview.

The overall prevalence of any disability increased between CFAS I and CFAS II, from 31.6% to 36.6%, this being due to an increase in mild/moderate disability (Appendix Table 2). Similarly the overall prevalence of dependency rose between CFAS I and CFAS II, from 39.6% to 45.5%, as a result of increases in low and high dependency (Appendix Table 2). When changes in both disability and dependency prevalence are examined in more detail, the picture by age differs between genders. In women, disability and dependency prevalence both increase between CFAS I and CFAS II in all age groups (Table 1). In men, disability and dependency prevalence increase in age groups 65-79 years and 90+ years but there is potentially a decrease in prevalence in age groups 80-89 years (Table 1).

Table 1: Inverse probability weighted prevalence of disability and dependency by age group and gender in CFAS I and CFAS II

	Men		Women	
Age	CFAS I % (n*)	CFAS II % (n*)	CFAS I % (n*)	CFAS II % (n*)
Disability				
65-69	11.3 (103)	15.5 (135)	18.4 (196)	19.4 (177)
70-74	13.9 (108)	18.5 (155)	20.9 (208)	29.7 (270)
75-79	22.5 (154)	23.6 (165)	33.5 (340)	42.8 (348)
80-84	36.3 (161)	33.8 (170)	53.0 (446)	59.8 (410)
85-89	60.5 (98)	55.7 (138)	72.1 (312)	75.1 (297)
90+	71.7 (25)	75.0 (53)	88.2 (164)	91.0 (158)
Dependency				
65-69	16.2 (146)	22.0 (197)	23.6 (250)	25.3 (229)

70-74	18.1 (140)	28.2 (239)	30.6 (304)	38.3 (351)
75-79	30.6 (208)	35.9 (253)	44.5 (449)	54.2 (440)
80-84	48.5 (212)	45.6 (232)	65.0 (536)	68.9 (483)
85-89	68.2 (105)	67.6 (167)	82.5 (348)	83.3 (324)
90+	82.3 (28)	83.8 (61)	94.0 (160)	95.5 (180)

*n = number with disability or dependency in age and gender group

Disability-free Life Expectancy

For men aged 65 total life expectancy increased between CFAS I and CFAS II by 4.6 years (95% CI: 3.7 – 5.5), with disability-free life expectancy increasing by 3.7 years (95% CI: 2.7 – 4.8) and years with disability by 0.8 years (95% CI: 0.3 – 1.4) (Table 2, Figure 1). Women's total life expectancy increased less, 2.1 years (95% CI: 1.1 – 3.0), with the majority, 2.0 years (95% CI: 1.0 – 2.9), being the increase in disability-free years and with an increase of only 0.1 years (95% CI: -0.7 – 0.9) in years with disability (Table 2). The proportion of life spent disability-free was similar for men in CFAS I and CFAS II (75.2% and 76.8% respectively, Table 2) and increased between the two studies for women (55.7% in CFAS I and 59.8% in CFAS II, Table 2).

Table 2: Total life expectancy (TLE), disability-free life expectancy and life expectancy with disability at age 65 years from CFAS I and CFAS II and the difference between the two studies, 95% confidence intervals (95%CI) in parentheses. For CFAS I men total N=2615, CFAS II men N=2866, CFAS I women N=3693 and CFAS II women N=3231.

	CFAS I	CFAS II	Difference (CFAS II – CFAS I)
Men	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Total life expectancy (years)	13.2 (12.6 – 13.8)	17.8 (17.1 – 18.4)	4.6 (3.7 – 5.5)
Disability-free (years)	9.9 (9.2 – 10.6)	13.7 (12.9 – 14.4)	3.7 (2.7 – 4.8)
Disability-free (% of TLE)	75.2 (73.5 – 76.9)	76.8 (75.3 – 78.4)	1.6 (-0.6 – 3.9)
With disability (years)	3.3 (2.9 – 3.6)	4.1 (3.7 – 4.5)	0.8 (0.3 – 1.4)
With disability (% of TLE)	24.8 (23.1 – 26.5)	23.2 (21.6 – 24.7)	-1.6 (-3.9 – 0.6)
Women	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)

Total life expectancy (years)	17.6 (17.0 – 18.2)	19.6 (18.9 – 20.3)	2.1 (1.1 – 3.0)
Disability-free (years)	9.8 (9.2 – 10.4)	11.7 (11.0 – 12.5)	2.0 (1.0 – 2.9)
Disability-free (% of TLE)	55.7 (54.1 – 57.3)	59.8 (58.1 – 61.4)	4.1 (1.7 – 6.4)
With disability (years)	7.8 (7.2 – 8.3)	7.9 (7.3 – 8.5)	0.1 (-0.7 – 0.9)
With disability (% of TLE)	44.3 (42.7 – 45.9)	40.2 (38.6 – 41.9)	-4.1 (-6.4 – -1.7)

The patterns of change over time at age 85 were similar to those at age 65 with increases over time in total life expectancy (men: 0.9 years, 95% CI 0.4 – 1.4; women: 0.6 years, 95% CI 0.1 – 1.1) and disability-free life expectancy (men: 0.8, 95% CI 0.3 – 1.3, women: 0.8 years, 95%CI 0.4 – 1.1) (Table 3). At age 85 the proportion of total life expectancy spent disability-free increased for women though not significantly for men (Table 3).

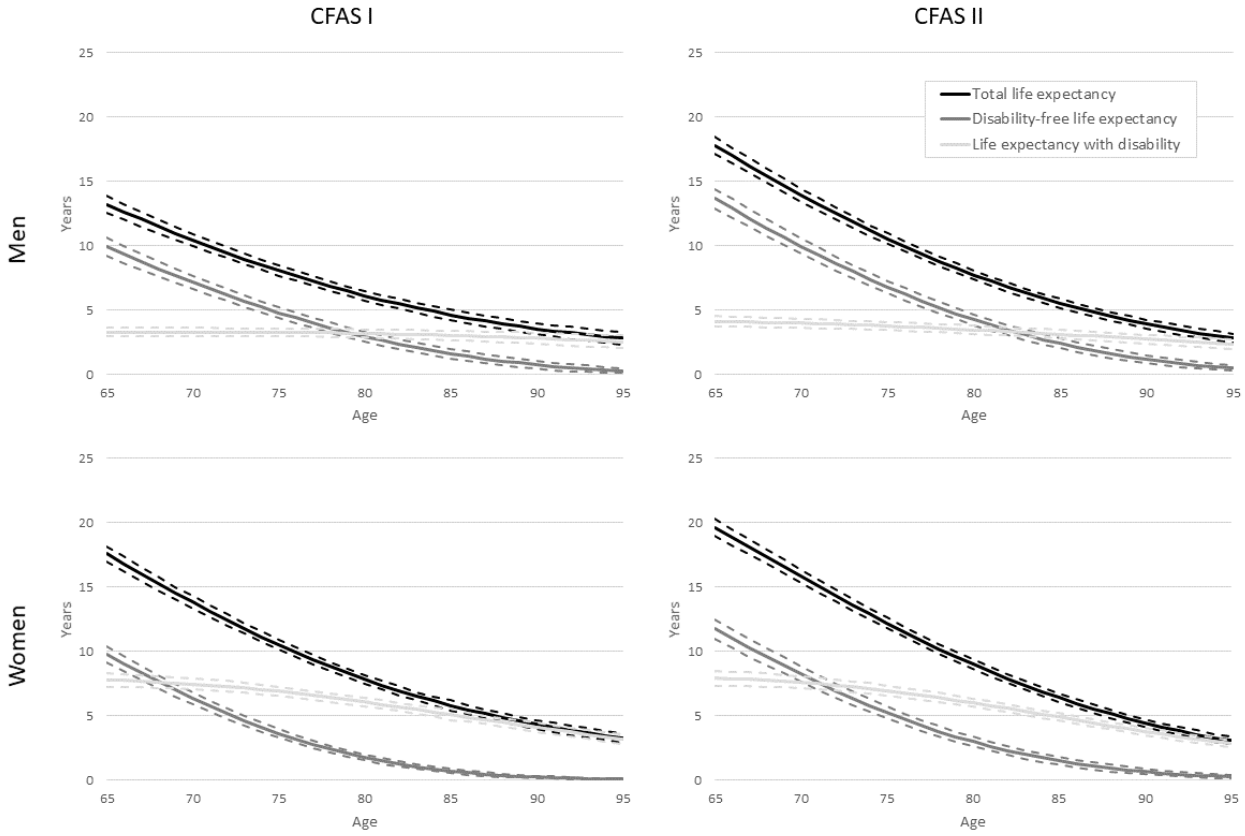
Total life expectancy, disability-free life expectancy and life expectancy with disability by age, gender and study are shown in Figure 1. Of note is the crossing point of the disability-free life expectancy and life expectancy with disability curves, this being the age at which the remaining years with and without disability are the same. In CFAS I this was 79 years for men and over 10 years earlier, at age 68 years for women, but by CFAS II these had increased by three years, to 82 years for men and 71 years for women.

Table 3: Total life expectancy (TLE), disability-free life expectancy and life expectancy with disability at age 85 years from CFAS I and CFAS II and the difference between the two studies, 95% confidence intervals (95%CI) in parentheses. For CFAS I men aged 85 years or above N=185, CFAS II men N=300, CFAS I women=542 and CFAS II women N=486.

	CFAS I	CFAS II	Difference (CFAS II – CFAS I)
Men	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Total life expectancy (years)	4.6 (4.2 – 5.0)	5.5 (5.2 – 5.9)	0.9 (0.4 – 1.4)
Disability-free (years)	1.6 (1.2 – 2.0)	2.4 (2.0 – 2.8)	0.8 (0.3 – 1.3)
Disability-free (% of TLE)	34.8 (27.9 – 41.6)	43.4 (37.8 – 49.0)	8.6 (-0.2 – 17.5)
With disability (years)	3.0 (2.6 – 3.4)	3.1 (2.8 – 3.4)	0.1 (-0.4 – 0.6)

With disability (% of TLE)	65.2 (58.4 – 72.1)	56.6 (51.0 – 62.2)	-8.6 (-17.5 – 0.2)
Women	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Total life expectancy (years)	5.8 (5.4 – 6.2)	6.4 (6.1 – 6.7)	0.6 (0.1 – 1.1)
Disability-free (years)	0.7 (0.5 – 0.9)	1.5 (1.2 – 1.8)	0.8 (0.4 – 1.1)
Disability-free (% of TLE)	12.3 (9.5 – 15.0)	23.4 (19.6 – 27.2)	11.1 (6.4 – 15.8)
With disability (years)	5.1 (4.6 – 5.5)	4.9 (4.6 – 5.2)	-0.2 (-0.7 – 0.4)
With disability (% of TLE)	87.7 (85.0 – 90.5)	76.6 (72.8 – 80.4)	-11.1 (-15.8 – -6.4)

Figure 1: Total life expectancy (TLE), disability-free life expectancy (DFLE) and life expectancy with disability (DLE) for men and women in CFAS I and CFAS II.



Probability of transitioning between disability states and death over time

One of the main purposes of estimating disability-free life expectancy with longitudinal data is the ability to examine the modelled probabilities of transitions between states (incidence, recovery, death from disability-free and disability) to see how these change over time. We show these in two ways. First, in Table 4, with the probability of each of these four transitions

between ages 65 and 69 years, 75 and 79 years, and 85 and 89 years. The probability of becoming disabled increases with age for both men and women in both studies, but is always higher for women than men, and is lower in CFAS II than CFAS I. The probability of recovery has the opposite pattern with age and again is more likely for men in CFAS II than CFAS I, though this is only true for women from age 75. Though at age 65 women are more likely to recover than men, by age 85 men have a slightly higher probability of recovery. The probability of death from either disability state from ages 65, 75 and 85, over the next five years increases with age, is higher for men than women, and has reduced over time (Table 4).

Table 4: Transition probabilities over five years between disability-free, disability and death states over specific ages for men and women in CFAS I and CFAS II

Gender	Study	Age from -> to	No disability to disability	No disability to death	Disability to no disability	Disability to death
Men	CFAS I	65 –> 69	0.10	0.11	0.31	0.37
		75 –> 79	0.21	0.22	0.16	0.50
		85 –> 89	0.33	0.41	0.06	0.64
	CFAS II	65 –> 69	0.08	0.04	0.39	0.22
		75 –> 79	0.18	0.12	0.23	0.37
		85 –> 89	0.31	0.33	0.10	0.57
Women	CFAS I	65 –> 69	0.17	0.05	0.47	0.13
		75 –> 79	0.38	0.12	0.17	0.26
		85 –> 89	0.53	0.29	0.04	0.46
	CFAS II	65 –> 69	0.15	0.05	0.47	0.09
		75 –> 79	0.31	0.08	0.22	0.21
		85 –> 89	0.47	0.21	0.07	0.43

In Table 5 comparison of the transition probabilities over time show that both men and women are less likely to become disabled in CFAS II compared to CFAS I (men relative risk (RR) = 0.8, 95% CI: 0.6 – 0.9; women: RR = 0.7, 95% CI: 0.6 – 0.8), also reflected in the overall transitions from baseline to follow-up (Appendix Table 3). Men are also less likely to die from either state in CFAS II compared to CFAS I, particularly from the disability-free state (RR = 0.5, 95% CI: 0.4 – 0.6) (Table 5 and Appendix Table 3).

Table 5: Relative risk (RR) of transitioning between disability states in CFAS II compared to CFAS I with 95% confidence intervals (CI)

	Men		Women	
Transition	RR*	95% CI	RR*	95% CI
No disability to disability	0.8	0.6 – 0.9	0.7	0.6 – 0.8
No disability to death	0.5	0.4 – 0.6	0.7	0.4 – 1.1
Disability to no disability	1.2	0.8 – 1.6	1.1	0.9 – 1.4
Disability to death	0.8	0.7 – 0.9	0.9	0.8 – 1.0

*RR from gender separate, study stratified model rather than study and gender separate

Dependency free life expectancy

Similar patterns emerged for years spent independent as to disability-free life expectancy. There were increases in remaining years independent at age 65 over time in men and women and an increase in years with dependency for men. This leads to little change in the proportion of life spent with and without dependency for men, but an increase in the proportion of life spent independent for women (Table 6).

Table 6: Total life expectancy, years spent independent and years spent with any dependency at age 65 years from CFAS I and CFAS II and the difference between the two studies, 95% confidence intervals (95%CI) in parentheses. For CFAS I men total N=2615, CFAS II men N=2866, CFAS I women N=3693 and CFAS II women N=3231.

	CFAS I	CFAS II	Difference (CFAS II – CFAS I)
Men	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Total life expectancy (years)	13.4 (12.8 – 14.0)	17.9 (17.3 – 18.5)	4.5 (3.6 – 5.4)
Independent (years)	9.4 (8.7 – 10.0)	12.8 (12.0 – 13.6)	3.5 (2.4 – 4.5)
Independent (% of TLE)	69.8 (68.0 – 71.6)	71.5 (69.8 – 73.1)	1.7 (-0.7 – 4.1)

With dependency (years)	4.0 (3.6 – 4.5)	5.1 (4.7 – 5.6)	1.1 (0.5 – 1.7)
With dependency (% of TLE)	30.2 (28.5 – 32.0)	28.5 (26.9 – 30.2)	-1.7 (-4.1 – 0.7)
Women	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Total life expectancy (years)	17.6 (17.0 – 18.2)	19.5 (18.8 – 20.2)	1.9 (1.0 – 2.8)
Independent (years)	8.0 (7.3 – 8.7)	10.5 (9.8 – 11.3)	2.5 (1.5 – 3.5)
Independent (% of TLE)	45.5 (43.9 – 47.1)	54.0 (52.3 – 55.7)	8.6 (6.2 – 10.9)
With dependency (years)	9.6 (9.0 – 10.2)	9.0 (8.3 – 9.6)	-0.6 (-1.5 – 0.3)
With dependency (% of TLE)	54.5 (52.9 – 56.1)	46.0 (44.3 – 47.7)	-8.6 (-10.9 – -6.2)

At age 85, years spent independent also showed an increase between CFAS I and CFAS II for both men and women (men: 0.8 years, 95% CI: 0.3 – 1.3; women: 0.5 years, 95% CI: 0.2 – 0.8). This results in an increase in the proportion of life spent independent (men: 10.5 percentage points, 95% CI: 2.2 – 18.9; women: 7.6 percentage points, 95% CI: 3.6 – 11.6) (Table 7).

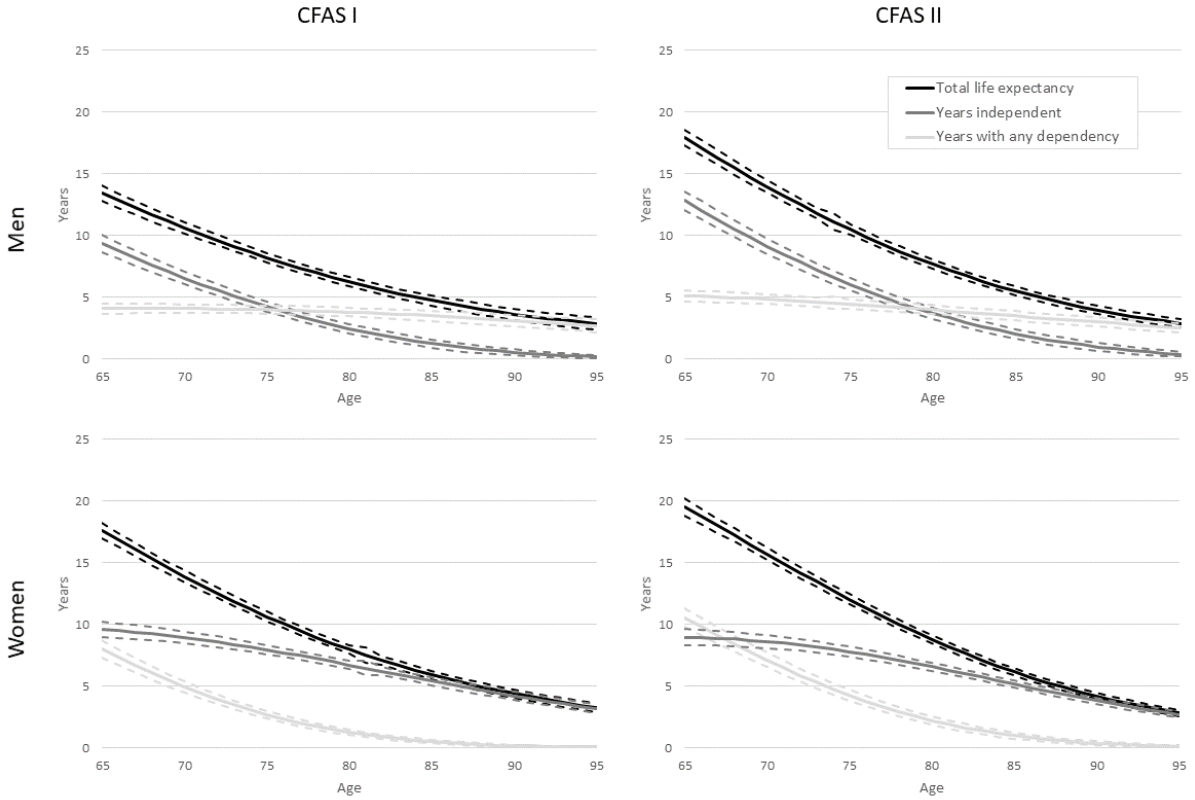
As for disability, the age at which the remaining number of years independent are equal to those dependent increased over time (Figure 2). In CFAS I this occurred at age 75 for men but prior to age 65 for women, whilst in CFAS II they had increased to 79 years for men and 67 for women.

Table 7: Total life expectancy, years spent independent and years spent with any dependency at age 85 years from CFAS I and CFAS II and the difference between the two studies, 95% confidence intervals (95%CI) in parentheses. For CFAS I men aged 85 years or above N=185, CFAS II men N=300, CFAS I women=542 and CFAS II women N=486.

	CFAS I	CFAS II	Difference (CFAS II – CFAS I)
Men	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Total life expectancy (years)	4.7 (4.3 – 5.2)	5.5 (5.1 – 5.9)	0.8 (0.2 – 1.3)
Independent (years)	1.2 (0.9 – 1.6)	2.0 (1.6 – 2.4)	0.8 (0.3 – 1.3)
Independent (% of TLE)	26.2 (19.9 – 32.6)	36.8 (31.3 – 42.2)	10.5 (2.2 – 18.9)
With dependency (years)	3.5 (3.1 – 3.9)	3.5 (3.1 – 3.8)	-0.0 (-0.6 – 0.6)

With dependency (% of TLE)	73.7 (67.4 – 80.1)	63.2 (57.8 – 68.7)	-10.5 (-18.9 – -2.1)
Women	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Total life expectancy (years)	5.9 (5.6 – 6.3)	6.2 (5.9 – 6.5)	0.2 (-0.2 – 0.7)
Independent (years)	0.5 (0.4 – 0.7)	1.0 (0.7 – 1.2)	0.5 (0.2 – 0.8)
Independent (% of TLE)	8.5 (6.2 – 10.9)	16.1 (12.8 – 19.4)	7.6 (3.6 – 11.6)
With dependency (years)	5.4 (5.1 – 5.8)	5.2 (4.9 – 5.4)	-0.3 (-0.7 – 0.2)
With dependency (% of TLE)	91.5 (89.1 – 93.8)	83.9 (80.6 – 87.1)	-7.6 (-11.6 – -3.6)

Figure 2: Total life expectancy (TLE), years spent independent and life expectancy with any dependency for men and women in CFAS I and CFAS II.



Probability of transitioning between dependency states and death over time

The probability of becoming dependent between ages 65 and 69, 75 and 79, and 85 and 89 years remained relatively stable over time for men but decreased for women, especially

younger women, and the probability of death decreased to a greater extent in men compared to women from both independent and any dependency (Table 8, Table 9). Recovery, the probability of returning to independence, also increased over time for men and younger women (Table 8) though not significantly overall for either (Table 9). As for disability, the decreased probability of dependency is also reflected in the overall probability of transitioning from baseline to follow-up dependency states (Appendix Table 4).

Table 8: Transition probabilities between independent, any dependency and death over specific ages for men and women in CFAS I and CFAS II

Gender	Study	Age from -> to	Independent to dependent	Independent to death	Dependent to independent	Dependent to death
Men	CFAS I	65 –> 69	0.12	0.11	0.35	0.29
		75 –> 79	0.25	0.21	0.16	0.43
		85 –> 89	0.37	0.39	0.05	0.60
	CFAS II	65 –> 69	0.11	0.03	0.46	0.17
		75 –> 79	0.22	0.12	0.23	0.33
		85 –> 89	0.33	0.33	0.08	0.54
Women	CFAS I	65 –> 69	0.25	0.05	0.39	0.11
		75 –> 79	0.46	0.11	0.13	0.23
		85 –> 89	0.57	0.28	0.03	0.43
	CFAS II	65 –> 69	0.17	0.05	0.45	0.07
		75 –> 79	0.36	0.08	0.18	0.18
		85 –> 89	0.52	0.23	0.05	0.41

Table 9: Relative risk (RR) of transitioning between dependency states in CFAS II compared to CFAS I with 95% confidence intervals (CI)

	Men		Women	
Transition	RR*	95% CI	RR*	95% CI

Independent to dependent	0.8	0.7 – 1.0	0.7	0.6 – 0.8
Independent to death	0.4	0.3 – 0.5	0.8	0.5 – 1.3
Dependent to independent	1.2	0.9 – 1.7	1.2	0.9 – 1.5
Dependent to death	0.8	0.7 – 0.9	0.9	0.9 – 1.0

*RR from gender separate, study stratified model rather than study and gender separate

Comparison of cross-sectional and longitudinal estimates

The previous cross-sectional estimates of disability-free and dependency-free life expectancy applied the observed age and gender specific prevalence of disability/dependency to period life tables. The longitudinal estimates reported here use the transitions between disability/dependency states, and are therefore more akin to cohort life tables. In addition the life expectancy produced from the longitudinal analyses are:

(i) based on study-specific mortality rather than the regional life tables from which the study emanates, and

(ii) formed from the sum of the individual state-specific life expectancies, e.g. disability-free life expectancy and years with disability.

This means that the total life expectancy from the disability analyses will not necessarily exactly match that from the dependency analyses.

For disability-free life expectancy the overall pattern for men is similar between the cross-sectional and longitudinal estimates with larger increases in total life expectancy at age 65, although the majority of this is formed of the increase in years disability-free. The same is true for dependency. These findings reflect the fact that the observed (cross-sectional) prevalence and the forward prevalence, formed from the transitions, are very similar (Appendix Figures 3 and 4). The same is not true however for women because the longitudinal estimates in CFAS I of total life expectancy are higher and of disability-free and dependency-free life expectancy are lower, resulting in a smaller increase in total life expectancy and a larger increase in disability-free/dependency-free life expectancy. Appendix Figure 3 shows that for women in CFAS I the observed prevalence of disability is lower than the period prevalence of disability and the same is true for dependency (Appendix Figure 4). This suggests that after CFAS I the prevalence of both disability and dependency would be expected to increase [9, 10], as is observed between CFAS I and CFAS II. In CFAS II the observed and period prevalence of disability (Appendix Figure 3) and dependency (Appendix Figure 4) are similar and therefore after CFAS II the prevalence of each is expected to remain stable. The increase in prevalence between CFAS I and CFAS II is likely to be due to longer survival with disability (Table 5 and Appendix Table 3 for disability, Table 9 and Appendix Table 4 for dependency). However the prevalence is likely to stabilise in the future as incident disability has decreased over time (Table 5 and Appendix Table 3 for disability, Table 9 and Appendix Table 4 for dependency). Thus the cross-sectional analysis was based on an increasing prevalence trend (Table 1 and Appendix Table 2) over time whereas the longitudinal analysis was based on the transitions between states where decreases in risk of incident disability/dependency and death from a disability-free/independent state override the decreasing risk of death from a

disabled/dependent state (Table 5 and Appendix Table 3 for disability, Table 9 and Appendix Table 4 for dependency).

Discussion

Main findings

Over the last two decades life expectancy at age 65 years in the CFAS cohorts increased by 4.6 years for men and by 2.1 years for women. Gains in life expectancy at age 85 were similar for men and women at 0.9 years and 0.6 years respectively. For men aged 65, the number of remaining years disability-free and with disability both increased so the proportion of remaining life spent disability-free was similar in both studies. However, for women aged 65, remaining years disability-free increased but years with disability were similar in both studies. This resulted in an increase in the proportion of remaining life spent disability-free (55.7% in CFAS I versus 59.8% in CFAS II).

The gains in disability-free years for both men and women were a result of decreases in the probability of becoming disabled and of a lower risk of death from a non-disabled state for men. The increase in years with disability for men resulted from a lower risk of death from a disabled state by CFAS II. Between CFAS I and CFAS II, there was a rise in the age at which expected remaining years with and without disability were equal, from 79 years to 82 years for men, and from 68 years to 71 years for women. Thus women reach this age over 10 years earlier than men.

Similar patterns occurred for dependency. Men spent a similar proportion of life remaining independent in CFAS I and CFAS II whilst women spent a greater proportion of remaining life independent in CFAS II compared to CFAS I (at age 65 years). Gains in independent years were again a result of a lower risk of becoming dependent for both men and women by CFAS II, and men had a reduced risk of death from either dependency state in CFAS II.

Strengths and Limitations

CFAS I and CFAS II are large studies and representative of the older population of the time the samples were drawn. Importantly, when studying disability and dependency, both studies include those living in care settings. The only change in study design was from the two stage screening and assessment approach for dementia diagnosis in CFAS I compared to a combined screening and assessment in CFAS II. This did not affect analyses as measures available only in the assessment interview (a0, see methods in Appendix) were not used here, and the separate wave two interviews in CFAS I (s2 and c2, see methods in Appendix) could therefore be analysed together, methodologically identical to the CFAS II data.

Initial response rates were lower in CFAS II compared to CFAS I [11], however, non-participation was associated with similar measures in both studies and the inverse probability weights accounted for these measures (see methods in Appendix). Bias in comparison analysis should therefore be minimal, as previously shown [2, 12]. Both CFAS I and CFAS II were linked with ONS mortality data so that exact date of death was available, the latest update for mortality data in CFAS II being two years after wave two. Although longer mortality follow up was available in CFAS I, we limited follow-up to be compatible with CFAS II. The single

follow-up meant that individuals who declined the invitation to wave two and were alive, had no recorded transitions and were therefore excluded from the analysis. To account for these, we applied further weights to those alive who participated in wave two to ensure population representativeness (see methods in Appendix).

Although both CFAS I and CFAS II were large population based studies, sometimes the number of transitions between states were low, particularly for recovery. Consequently the analysis has, to date, been restricted to binary measures of disability and dependency. As reported in the results section two questions needed to define dependency were omitted in one of the CFAS I interviews but were present in the other CFAS I interviews and in all CFAS II interviews. The omitted questions were 'difficulty with toileting' to define high dependency and 'difficulty with light housework' to define low dependency. The sensitivity analysis showed that replacement of toileting with incontinence provided a similar estimate of dependency prevalence in CFAS II compared to the original dependency measure.

Comparison between cross-sectional and longitudinal results

In contrast to previously published CFAS estimates using the cross-sectional prevalence of disability and dependency [2, 3], these longitudinal estimates suggest a larger increase over time in the proportion of life spent disability-free for women at age 65. This difference is likely to stem from differences in cross-sectional and longitudinal analyses. Whereas cross-sectional analysis of disability-free life expectancy is based on disability prevalence, longitudinal analysis is based on transitions between disability states and death. As shown in the results section, the trends in prevalence of disability differ to trends in incidence and mortality. Prevalence of disability/dependency is increasing over time, whereas decreases in incidence of disability/dependency and mortality from a disability-free/independent state outweigh decreases in mortality from disability/dependency.

The ONS regularly reports on healthy life expectancy and disability-free life expectancy using cross-sectional data on health status from the General Lifestyle Survey. The latest release was in 2018 but temporal trends in disability-free life expectancy could not be reported due to changes in the questions used to measure disability [13]. In 2014 the ONS reported healthy and disability-free life expectancy based on cross-sectional data from 2009-2011 (a similar time to CFAS II) in comparison to 2000-2002 [14]. Total life expectancy from the ONS for 2009-2011 was similar for men and women in CFAS II. Although the temporal comparisons from the ONS were over a decade rather than two decades, their estimates differed to both the CFAS cross-sectional and longitudinal results, ONS reporting an increase in the proportion of life spent disability-free for men and a similar proportion of life spent disability-free for women between 2000-2002 and 2009-2011 [14]. However it should be noted that ONS estimates of healthy life expectancy and disability-free life expectancy between censuses do not include the population in residential care.

Conclusion

Over the past two decades there has been an increase in the remaining years spent free of disability and of years independent at age 65 in men and women. These appear to be due to a lower probability of becoming disabled or dependent for both men and women, as well as

lower probabilities of death from non-disabled or independent states for men. Women spend more years with disability or dependency than men, and women reach the age where the remaining years with and without disability are equal some 10 years earlier than men. Trends over time have proven more beneficial for women than men in that the proportion of total life expectancy spent disability-free increased for women but remained stable for men. However, men still spend a greater proportion of remaining life disability-free than women. Although men would still benefit from a delay of disability or dependency onset, our analyses show the importance of delaying disability and dependency in women so that a greater proportion of their remaining life is independent and free of disability. Future work will examine the trends in years with disability/dependency further by estimating the years spent with different levels of severity of disability/dependency. In addition we will investigate the impact of different long-term conditions, both singly and together, on years with disability, specifically whether individual long-term conditions, and multi-morbidity, have become more/less disabling or fatal.

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Appendix

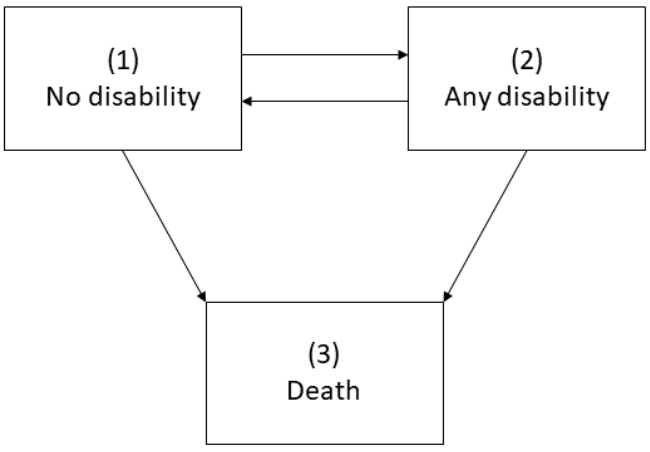
Methods

In CFAS I baseline interviews were split into a screen (s0 [4]) and assessment (a0 [4]). In the screening interview participants were asked questions on demographics, health, cognition, social contact, lifestyle, service use whilst various other topics, including dementia and depression, were assessed in a0. At the two year follow up interview participants had a second screen (s2 [4]) and potentially an assessment (a2 [4]), unless they had a baseline assessment interview in which case at two year follow-up they had a combined screening and assessment (c2 [4]). For the analyses reported here only the baseline screening (s0), and the two year follow up screening (s2) and combined interview (c2) were used. In comparison CFAS II used a combined screening and assessment interview on all participants at baseline and two year follow up.

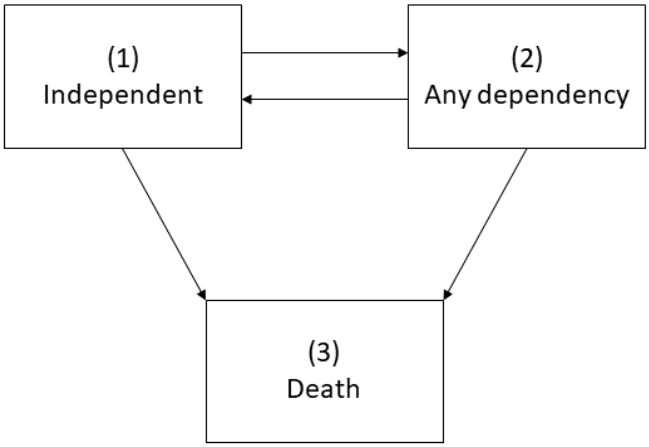
Statistical analysis

The original cross-sectional comparisons of disability-free life expectancy and dependency-free life expectancy at age 65 in 1991 and 2011 applied the baseline prevalence of disability/dependency by age group and gender from the Cognitive Function and Ageing Studies (CFAS I and CFAS II) to regional life tables (the regions being the three centres covered by CFAS I and CFASII). For the longitudinal analyses in this project, multistate models were used to estimate transitions between, for example, disability-free and disability states and death. Disability and dependency progression and recovery were both modelled, making death the only absorbing state. Disability was grouped into no disability or any disability (Appendix Figure 1) and dependency into independent versus any dependency (Appendix Figure 2). Further analyses will report other cutpoints encompassing severity levels of dependency although sparsity of some transitions are resulting in the current models failing to converge.

Appendix Figure 1: Transitions in a multistate model with any disability and death.



Appendix Figure 2: Transitions between independence, any dependency and death



Interpolated Markov Chain (IMaCh) software version 0.99r19 was used to estimate total life expectancy and life expectancy with and without disability or dependency [9]. This method models time discretely, but to approximate the underlying continuous time structure the interval between interviews can be decomposed into several shorter one month steps. Multinomial logistic regression is then used to model the transition probabilities for each of the shorter steps. Total life expectancy was calculated using date of birth and date of death. Date of death was routinely received from the Office of National Statistics for both CFAS I and CFAS II and, for comparability of follow-up between CFAS I and CFAS II, death up to two years after the second wave interview was included in the analysis. Life expectancies with and without disability/dependency were estimated using the multistate models described above on transitions between baseline and two year follow up interviews of CFAS I and CFAS II. Separate analyses were conducted for men and women in CFAS I and CFAS II.

Analyses were inverse probability weighted to ensure population representativeness and account for the sampling design (oversampling of those aged 75 years and over). Anyone who died before the censoring date (two years after the two-year follow up interview) were baseline weighted for age, gender and deprivation. Those still alive by the censoring date were excluded from the analysis if they did not participate in wave two interviews as they did not transition during the time observed and therefore would not contribute to the likelihood of the model. Since these were more likely to have severe disability and might therefore result in an underestimate of recovery and an overestimate of mortality from the disabled state, we calculated a further weighting factor (based on age, gender, centre, cognitive function, disability, education, social class, deprivation, number of health conditions, self-rated health, smoking) and applied this (in addition to the baseline sampling weight) to participants who had not died by the censoring date but who did participate in wave two interviews. Appendix Table 1 has baseline characteristics by status of inclusion in wave 2 for CFAS II. For the equivalent in CFAS I please see Matthews et al. [15].

Appendix Table 1: Baseline characteristics by status of wave two inclusion in CFAS II

Factor		**Interviewed (n=5288)**		**Died (n=645)**		**Lost (n=1829)**	
		n	%	n	%	n	%
Sex	Women	2806	54.3	349	58.4	1073	60.1
Age (years)	65 – 69	1479	26.2	52	6.6	408	20.8
	70 – 74	1369	24.7	75	10.1	429	22.4
	75 – 79	1122	21.1	96	13.2	406	21.7
	80 – 84	803	16.2	160	24.3	315	18.1
	85 – 89	399	8.6	143	21.5	195	11.5
	90+	116	3.3	117	24.3	78	5.5
Place of residence	Community	4959	92.4	485	72.8	1639	88.3
	Semi-dependent housing	284	6.3	69	12.0	129	7.8
	Care settings	45	1.3	89	15.2	63	3.9
Deprivation	Least deprived	1873	31.2	166	22.3	537	25.5
	Middle deprived	1809	32.7	207	31.8	604	30.8
	Most deprived	1606	36.1	270	45.9	690	43.7
Social Class	Skilled	1491	27.6	124	23.0	343	19.7
	Semi-skilled	2761	54.3	286	53.3	915	54.7
	Unskilled	851	18.0	120	23.7	399	25.6
Education (years)	≤9	1182	24.9	293	50.5	570	33.9

	10 – 11	2769	52.0	225	34.7	931	51.1
	≥12	1288	23.1	94	14.7	285	15.0
Marital status	Married	3151	56.9	251	36.4	991	51.5
	Single/divorced	683	13.6	74	11.8	248	14.7
	Widowed	1442	29.6	302	51.8	578	33.8
Functional Impairment	None	3758	69.5	155	24.7	1065	59.7
	Mild/Moderate	1008	20.4	120	21.7	370	22.7
	Severe	466	10.1	279	53.6	257	17.6
Dementia		105	2.3	166	29.0	190	12.2
MMSE Score	0 – 17	76	1.8	69	13.6	68	4.8
	18 – 21	161	3.4	69	13.9	116	7.2
	22 – 25	758	15.2	134	24.9	397	24.1
	26 – 30	4251	79.7	280	47.7	1128	63.9
Number of Comorbidities	0	454	8.3	43	6.7	156	8.4
	1	937	17.1	78	12.0	306	16.3
	2	1210	22.6	105	15.3	384	21.0
	3+	2677	52.1	405	65.9	956	54.4
Self-perceived health	Excellent	1116	20.7	61	12.0	307	18.1
	Good	2763	52.3	215	41.9	834	48.8
	Fair	1117	22.2	163	30.0	432	26.8

	Poor	239	4.8	87	16.2	101	6.4
Self-reported depression	Depressed	386	7.5	45	8.1	148	9.0
Loneliness	Lonely	808	16.3	143	27.3	297	18.5
Friendships	Has friends	4587	86.7	465	76.4	1489	82.1
Smoking	Never	2050	38.8	160	31.9	629	37.7
	Past	2513	48.2	263	51.3	754	44.9
	Current	654	13.0	90	16.7	280	17.5
Alcohol intake	5 or more days a week	1151	21.5	94	18.0	308	18.0
	1 – 4 days a week	1665	31.5	104	20.1	446	26.2
	1 – 4 times every 2 months	896	17.1	80	14.6	267	15.9
	0 – 2 times a year	1492	29.9	225	47.3	636	40.0

Results

Appendix Table 2: Numbers at baseline and inverse probability weighted prevalence in CFAS I and CFAS II

		CFAS I % (n)	CFAS II % (n)
N		(7635)	(7762)
Age group	65-69	25.0 (1981)	23.0 (1939)
	70-74	22.8 (1776)	22.7 (1873)
	75-79	22.5 (1725)	20.5 (1624)
	80-84	17.7 (1308)	17.5 (1278)

	85-89	8.5 (615)	10.5 (737)
	90+	3.5 (230)	5.8 (311)
Gender	Men	39.2 (3045)	43.9 (3534)
	Women	60.8 (4590)	56.1 (4228)
Disability	None	68.5 (5236)	63.4 (4978)
	Mild/Moderate	14.1 (1048)	21.1 (1498)
	Severe	17.5 (1267)	15.5 (1002)
Dependency	Independent	60.4 (4574)	54.5 (4300)
	Low dependency	28.8 (2117)	33.4 (2344)
	Medium dependency	6.8 (488)	6.1 (410)
	High dependency	3.9 (281)	6.0 (402)

Appendix Table 3: Disability state at wave two by disability state at baseline, men and women for CFAS I and CFAS II. Deaths that occurred before wave two interview, not all used in multi-state models.

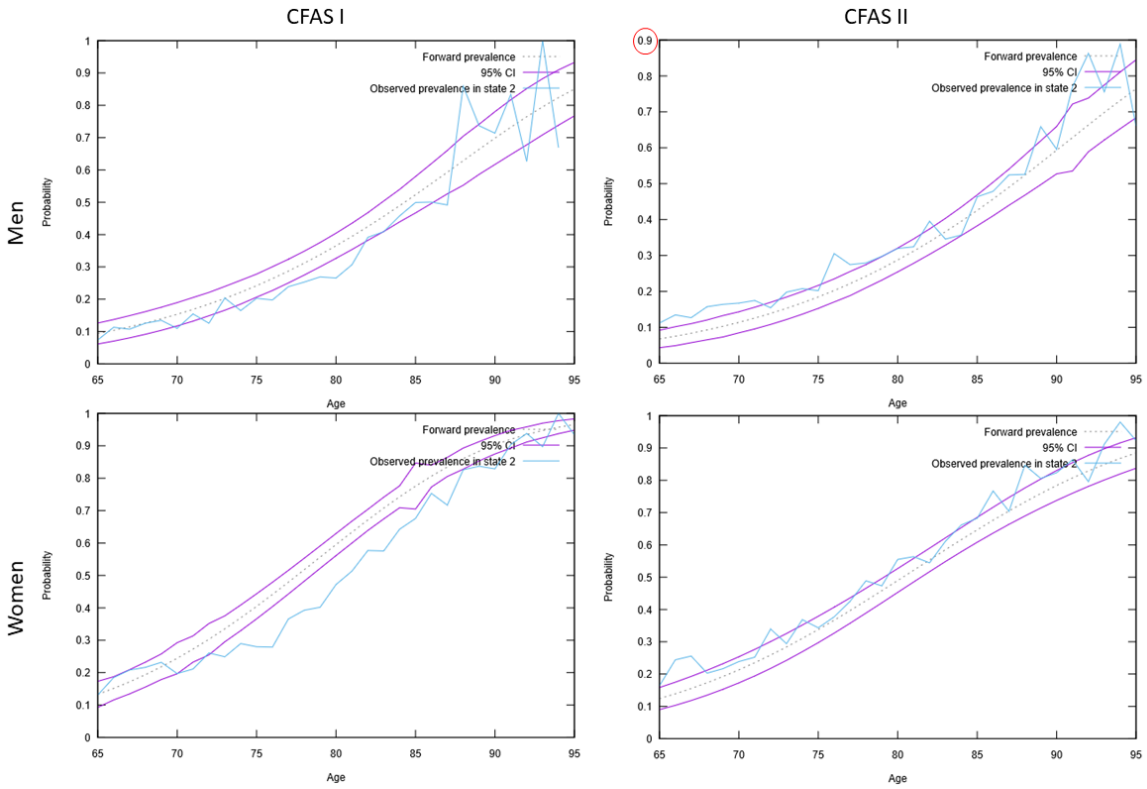
	No disability (w2)	Disabled (w2)	Dead (w2)	Total %
Men				
CFAS I				
No disability (s0)	76.6 (1474)	13.8 (261)	9.7 (183)	100
Disabled (s0)	12.5 (63)	48.4 (240)	39.1 (193)	100
CFAS II				
No disability (w1)	83.6 (1751)	11.4 (224)	5.0 (99)	100
Disabled (w1)	18.2 (125)	54.4 (343)	27.3 (160)	100

Women				
CFAS I				
No disability (s0)	69.7 (1511)	24.4 (519)	5.9 (126)	100
Disabled (s0)	10.0 (126)	65.4 (794)	24.6 (289)	100
CFAS II				
No disability (w1)	77.2 (1432)	19.5 (338)	3.3 (56)	100
Disabled (w1)	13.8 (183)	65.0 (800)	21.2 (229)	100

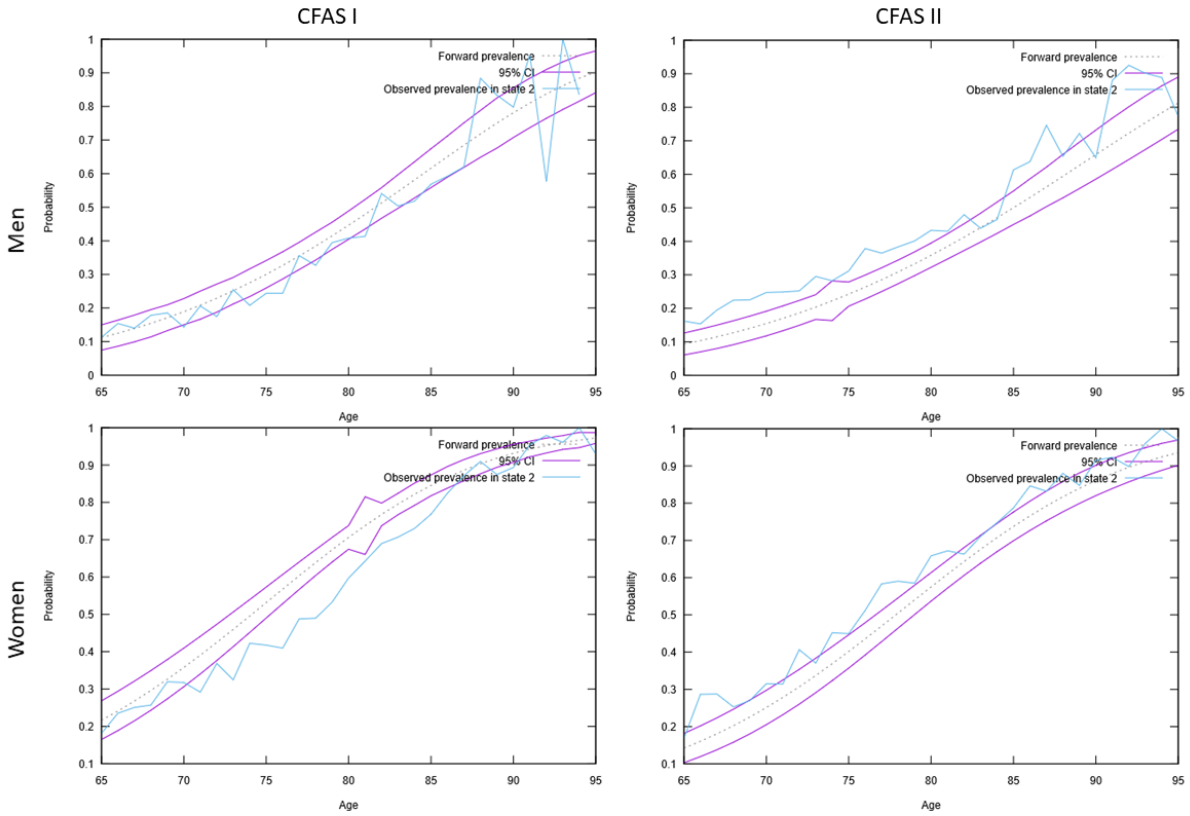
Appendix Table 4: Dependency state at wave two by dependency state at baseline, men and women for CFAS I and CFAS II. Deaths that occurred before wave two interview, not all used in multi-state models.

	Independent (w2)	Dependent (w2)	Dead (w2)	Total %
Men				
CFAS I				
Independent (s0)	74.8 (1302)	15.8 (271)	9.4 (161)	100
Dependent (s0)	12.2 (80)	55.7 (359)	32.1 (205)	100
CFAS II				
Independent (w1)	82.3 (1486)	13.5 (229)	4.2 (70)	100
Dependent (w1)	18.1 (171)	58.6 (504)	23.3 (192)	100
Women				
CFAS I				
Independent (s0)	66.6 (1202)	28.3 (504)	5.1 (91)	100
Dependent (s0)	8.5 (131)	70.4 (1057)	21.1 (306)	100
CFAS II				
Independent (w1)	74.8 (1171)	21.7 (323)	3.4 (49)	100
Dependent (w1)	11.8 (191)	68.4 (1009)	19.8 (247)	100

Appendix Figure 3: Cross-sectional (observed) and period (forward) prevalence of disability



Appendix Figure 4: Cross-sectional (observed) and period (forward) prevalence of dependency



Sensitivity analyses

In CFAS I two questions required to define dependency were omitted in one of the interviews (wave c2 – see methods in Appendix for wave structures) but were present in all other CFAS I and CFAS II interviews. The omitted questions were 'difficulty with toileting' to define high dependency and 'difficulty with light housework' to define low dependency. Incontinence, difficulty putting on shoes and socks and difficulty with household tasks such as making a cup of tea were tested in variations to replace the omitted questions. Sensitivity analysis were carried out in CFAS II where all the questions were present. Without the omitted variables prevalence of high dependency was low (Alternate 1, Appendix Table 5) in comparison to the original measure (Appendix Table 2 and 5). Initially as a replacement for toileting, difficulty with putting on shoes and socks in addition to incontinence addressed the physical part of getting to the toilet, though the prevalence of high dependency remained low in comparison to the original (Alternate 2, Appendix Table 5). Then incontinence alone was used as a replacement (Alternate 3, Appendix Table 5). Difficulty with household tasks such as making a cup of tea was tested as a replacement for difficulty with light housework but in comparison to the original this slightly underestimated independence (Alternate 4, Appendix Table 5). Given that all levels of dependency would be grouped together to give any dependency Alternate 3 was chosen as a compromise as this would give the most similar prevalence of independence versus any dependency compared with the other alternatives.

Appendix Table 5: Prevalence of dependency in CFAS II at baseline using different replacement variables for missing CFAS I wave c2 variables

	Original[1]	Alternate 1[2]	Alternate 2[3]	Alternate 3[4]	Alternate 4[5]
Independent	54.5	56.3	56.2	55.1	53.2
Low dependency	33.4	34.1	34.1	32.2	34.1
Medium dependency	6.1	6.5	6.3	5.9	5.9
High dependency	6.0	3.2	3.5	6.8	6.8

[1]Original: Including the variables that were omitted from CFAS I wave c2 (same as prevalence given in Appendix Table 2). [2]Alternate 1: Excluding variables omitted from CFAS I wave c2 (toileting from high dependency and light housework from low dependency). [3]Alternate 2: Excluding variables omitted from CFAS I wave c2 and replacing toileting with being incontinent and also having difficulty putting on shoes and socks. [4]Alternate 3: Excluding variables omitted from CFAS I wave c2 and replacing toileting with being incontinent. [5]Alternate 4: Excluding variables omitted from CFAS I wave c2, replacing toileting with being incontinent and replacing light housework with difficulty with household tasks such as making a cup of tea.

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