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MORTALITY

Secular trends of mortality and dementia-free life expectancy over a 10-year period in France

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Abstract

The aim of this paper was to investigate the evolution of mortality and life expectancy according to dementia in two French populations 10 years apart. Two different populations of subjects aged 65 or older included in PAQUID from 1988 to 1989 (n = 1342) and 3C from 1999 to 2000 (n = 1996) and initially not demented were followed over 10 years. Dementia was assessed using an algorithmic approach, and participants were considered to have dementia if they had an MMSE score < 24 AND a 4IADL score > 1. Illness-death models were used to compare mortality with and without dementia and to provide total life expectancy (LE), dementia-free life expectancy (DemFreeLE), life expectancy with dementia (DemLE), and survival with dementia. Mortality without dementia has decreased between the two populations among men [HR = 0.63 (0.49–0.81)] and women [HR = 0.67 (0.50–0.90)], whereas mortality with dementia has decreased for women only [HR = 0.59 (0.41–0.87)]. Total LE and DemFreeLE have increased between the 1990s and the 2000s populations (total LE: + 2.5 years; DemFreeLE: + 2.2 years); DemLE only slightly increased between the populations (DemLE: + 0.3 years). For survival with dementia, an increase in survival has been evidenced (mean survival: + 1.3 years) for women only. The improvement in DemFreeLE is promising. However, as the duration of life with dementia tends to increase for women, efforts to delay the onset of dementia should be reinforced.

Keywords Secular trends · Dementia · Mortality · Life expectancy

Introduction

According to the World Health Organization, the worldwide average life expectancy at age 60 years was 21.5 years for women and 18.5 for men in 2012, whereas it was 19.7 and 16.6 years for women and men, respectively, in 1990 [1]. In most high-income countries worldwide, this increase in life expectancy (LE) at age 60 is even greater, with an increase by approximately 2 years per decade [1]. LE is expected to continue increasing in several countries up to 2030 [2]. Given that the major risk indicator for dementia is age, the number of persons at risk of becoming demented is expected to rise. Indeed, the forecasted number of dementia cases worldwide has been estimated at 74.7 million in 2030 and 131.5 in 2050 [3]. Due to the high burden of dementia impacting not only the patients but also their families and society, it is critical to explore any evolution of life expectancies with and without the disease. However, if the increase in global life expectancy is known, the increase in life expectancy according to dementia status has been poorly investigated. However, in high-income countries, quality of life has become as important as the number of remaining years to live, and real progress in life expectancy should be associated with an increase in the number of years spent in a healthy state without disease. Three scenarios can apply. First, an overall increase in LE associated with extra years of life spent in good health (without dementia) is referred to

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as a compression of morbidity [4]. Then, if the extra years of LE are spent in poor health (with dementia), it is defined as expansion of morbidity [5]. Alternately, the number of unhealthy years with dementia can increase, but the proportion of life spent healthily is increasing or decreasing, resulting in either a relative compression or a relative expansion [6].

Nevertheless, several studies have shown decreasing trends in the prevalence and incidence of dementia over the last three decades [7, 8]. However, only a few papers have investigated changes over time in mortality and/or survival among people free of dementia and with dementia [9–12]. Life expectancies are related to both mortality and the incidence or prevalence of dementia. Studies investigating the secular trends of life expectancies lack evidence for which scenario could be accurate.

In a previous paper, we published the decrease in the incidence of dementia found in women between two French populations 10 years apart [7]. In this study, we aimed to investigate within the same populations whether the improvement of mortality over the time is similar between participants with or without dementia, as well as which factors could be related to the evolutions of the secular trends. Moreover, we established life expectancies [total life expectancy (total LE), LE free of dementia (DemFreeLE), and LE with dementia (DemLE)] and duration of life with dementia.

Methods

Study population

This study is based on two prospective population-based cohorts in the Bordeaux area of France (PAQUID and Three-City), the same populations that have already been used in our previous publication regarding secular trends in dementia incidence [7]. Participants aged 65 and over living in the community were randomly chosen from the electoral rolls for both cohorts.

The Personnes Agées Quid (PAQUID) cohort was formed in 1988–1989 with a representative sample of 3777 participants living at home in the departments of Gironde and Dordogne. The selection was stratified by sex, age, and size of urban unit. For this paper, only participants from the Urban Community of Bordeaux (n = 1469) have been selected from PAQUID. The Three-City (3C) cohort started in 1999 and recruited 2104 participants from the Urban Community of Bordeaux, within 10 districts. For both cohorts, a standardized questionnaire assessing sociodemographic, medical, cognitive, and functional data was administered by trained neuropsychologists during face-to-face interviews at baseline and at each follow-up (3, 5, 8, and 10 years for PAQUID and 2, 4, 7, and 10 years for 3C) (supplementary figure 1). Participants were followed up even if they moved to a care home. At each follow-up, vital status was systematically recorded for all the participants. Full details of the studies have been described elsewhere [13, 14].

Thus, 1469 subjects from PAQUID (hereafter referred to as the 1990s population; baseline screening response rate 60%) and 2104 subjects from 3C (hereafter referred to as the 2000s population; baseline screening response rate 39%) were available. After the exclusion of prevalent dementia cases (algorithmically diagnosed) and missing values for adjustment factors, the study population was thus composed of 1342 participants for the 1990s population and 1996 participants for the 2000s population [7].

Diagnosis of dementia

To diagnose dementia consistently between generations, an algorithmic approach has been used, as previously published [7]. This algorithmic diagnosis was based on cognitive and functional assessments, using the Mini Mental State Examination (MMSE) [15] and the 4 Instrumental Activities of Daily Living (IADL) scores (adding up the 4 most cognitive IADL: using the telephone, using transportation, handling medications, and managing budget) [16]. For each activity, participants were considered disabled for the first level of disability; thus, the scores range from 0 for a completely unimpaired subject to 4 for a person who is disabled for the four activities. Considering the older ages of the participants and the associated high proportion of subjects restricted in transportation, we considered limitations in activities from more than one restricted activity out of the four [17]. The algorithmic diagnosis of dementia was then defined by an MMSE score < 24 (or a missing MMSE score for “cognitive reason”) AND a 4IADL score > 1.

Baseline characteristics

Several risk factors were controlled for in statistical models. First, sociodemographic factors such as gender and educational level (validated primary school level or short secondary school level, long secondary school level or more, and no diploma). Then, vascular-related factors were considered: history of stroke, as well as treatment with anti-hypertensive drugs, lipid-lowering drugs, and anti-diabetic drugs as proxies for vascular risk factors. Data on treatments were collected using a standardized questionnaire as well as visual inspection of the participants’ medicine packs.

Statistical analyses

The two populations were compared in terms of sociodemographic and health factors, as well as for cognitive (MMSE score) and functional abilities (4IADL score) at baseline.

The subsequent analyses comparing secular trends between the two populations have been established with an illness-death model using the SmoothHazard Package [18]. This multi-state model describes the pathway from a healthy state (here, without dementia) to an absorbing state (death) either directly or through a demented state (supplementary figure 2) [19]. A semi-parametric approach using penalized likelihood approximating by M-splines was used to provide transition intensities, and left truncation and interval censoring were accounted for. To estimate mortality hazard ratios (HR) according to dementia status, we pooled the two samples, with population as a binary factor ($HR_{2000s\ population\ vs\ 1990s\ population}$); given the differences by gender, two separate models for men and women have been evaluated. Age was used as the basic time scale in the analyses, so the incidence of dementia is age-specific. To investigate to what extent risk factors explained the evolution of mortality risk, additional adjustments were made: (1) educational level; (2) vascular risk factors; and (3) both educational level and vascular risk factors. To explore the effect of a potential response bias due to differential participation rates, we performed a sensitivity analysis. Several samples of refusals were simulated using Weibull distributions, estimated on the 2000s responders in order to complete the 2000s sample and reach response rate of 60% as in the 1990s sample. Four different scenarios hypothesizing higher risk of dementia and death (without dementia) among refusals compared to individuals agreeing to participate were tested using higher risk of dementia of 1.25 or 1.5 and higher risk of death of 1.25 or 1.5.

The SmoothHazard package also estimates transition probabilities, cumulative event probabilities and life expectancies. These parameters have been obtained separately in two models for each of the two populations. Models were adjusted by gender and educational level (the two highest levels were combined to compare participants with or without a diploma). The following predictive parameters were computed: (1) the total life expectancy (total LE); (2) the LE free of dementia (DemFreeLE); (3) the LE with dementia (DemLE) (corresponding to the difference between total LE and DemFreeLE); and (4) the duration of life/survival with dementia. DemFreeLE at a given age was defined as the average number of years an individual who attained that age without dementia was expected to live free of dementia. DemLE at a given age can be defined as the average number of years an individual who attained that age without dementia was expected to live with dementia. It must be differentiated from the survival with dementia, which corresponds to the average number of years an individual who has attained the state of dementia at a given age is expected to live with the disease. Both indicators serve different interests; DemLE is more relevant from a public health point of view at a collective level, and survival with dementia is more relevant from a clinical point of view at an individual level, or for the patient himself.

Results

The comparison of the two populations (1342 participants for the 1990s population and 1996 participants for the 2000s population) is described in Table 1. The mean age at baseline did not differ between the two populations; however, the 1990s population had more participants aged 85 and above at baseline than the 2000s population did. Educational level highly improved between populations. Participants from the 2000s population had, at baseline, better health parameters than participants from the 1990s population in terms of stroke history, treatment against hypertension, hypercholesterolemia (no differences for anti-diabetics), and cognitive and functional status. These comparisons remained similar after age-adjustment. The mean age (SD) at the time of diagnosis of algorithmic dementia over the follow-up was 81.5 y.o. (6.9) for the 1990s population and 81.9 y.o. (6.5) for the 2000s population in men; and 83.0 y.o. (5.8) for the 1990s population and 82.7 y.o. (4.8) for the 2000s population in women.

Risks of death were compared between the two populations (2000s vs. 1990s) for people with and without dementia (Table 2). For women, the risk of death without becoming demented was lower among the participants of the second population than among those of the first population [in women, HR = 0.67 (0.50–0.90)]. This risk decrease did not materially change after adjustment for educational level and vascular factors [HR = 0.59 (0.43–0.81)]. The risk of death after developing dementia was also lower for women of the second population than for those of the first population, even in the fully adjusted model [HR = 0.61 (0.40–0.92)]. For men, mortality without dementia was also lower in the second generation than in the first one, even after adjustment [HR = 0.66 (0.49–0.88)]. However, mortality for men with dementia did not differ by generations [HR = 1.13 (0.64–1.98)]. Sensitivity analysis assuming higher risks for dementia and death without dementia for the refusals is presented in supplementary table 1. For women, mortality decrease with or without dementia remained significant in the four scenarios tested, though the decrease became lower in scenarios where the risk of death was increased by 50%. For men, mortality without dementia for men became non-significant only when an increased risk of 1.5 for both dementia and death risk was applied to refusals after further adjustment on education [education adjusted HR = 0.83 (0.66–1.03)].

Table 3 reports the total LE, the DemFreeLE and the DemLE according to the population for different ages. Globally, total LE and DemFreeLE significantly increased

Table 1 Characteristics of the two populations at baseline (N = 3338)

	1990s population N = 1342	2000s population N = 1996	*p* value	Age adjusted *p* value*
Gender (women)	815 (60.7)	1211 (60.7)	0.97	0.94
Mean age at baseline	74.3 (6.5)	74.4 (5.0)	0.67	–
Age at baseline			< 0.001	–
65–69 years	445 (33.2)	461 (23.1)		
70–74 years	313 (23.3)	672 (33.7)		
75–79 years	320 (23.8)	580 (29.1)		
80–84 years	163 (12.1)	234 (11.7)		
85 + years	101 (7.5)	49 (2.4)		
Educational level			< 0.001	< 0.001
No diploma	312 (23.2)	230 (11.5)		
Intermediate school level	825 (61.5)	1091 (54.7)		
High school level	205 (15.3)	675 (33.8)		
Stroke history	67 (5.0)	65 (3.3)	0.012	0.017
Anti-hypertensive treatment	701 (52.2)	1137 (57.0)	0.007	0.009
Anti-diabetic treatment	97 (7.2)	147 (7.4)	0.88	0.88
Lipid-lowering treatment	161 (12.0)	636 (31.9)	< 0.001	< 0.001
Mean MMSE score at baseline[a]	26.6 (2.7)	27.4 (2.0)	< 0.001	< 0.001
4 IADL at baseline[a]			< 0.001	< 0.001
0	1059 (79.0)	1724 (86.6)		
1	209 (15.6)	214 (10.7)		
2	47 (3.5)	33 (1.7)		
3	15 (1.1)	13 (0.6)		
4	11 (0.8)	7 (0.4)		

MMSE, Mini Mental State Examination; 4 IADL, instrumental activities of daily living

[a] Missing data: MMSE (n = 59); 4 IADL (n = 6)

*p value adjusted for age at baseline

Table 2 Mortality evolution between the 1990s and the 2000s population, by gender

	Men N = 1312		Women N = 2026	
	HR (95% CI)	*p*	HR (95% CI)	*p*
Transition 0–2 (healthy to death) 2000s versus 1990s				
Unadjusted	0.63 (0.49–0.81)	< 0.001	0.67 (0.50–0.90)	0.008
Adjusted on education	0.72 (0.56–0.92)	0.01	0.67 (0.48–0.92)	0.01
Adjusted on vascular factors[a]	0.57 (0.43–0.74)	< 0.001	0.61 (0.45–0.81)	< 0.001
Fully adjusted[b]	0.66 (0.49–0.88)	0.005	0.59 (0.43–0.81)	< 0.001
Transition 1–2 (dementia to death) 2000s versus 1990s				
Unadjusted	1.13 (0.64–1.98)	0.68	0.59 (0.41–0.87)	0.007
Adjusted on education	0.83 (0.49–1.42)	0.51	0.53 (0.35–0.78)	0.002
Adjusted on vascular factors[a]	1.30 (0.75–2.24)	0.34	0.69 (0.46–1.03)	0.07
Fully adjusted[b]	0.80 (0.45–1.43)	0.46	0.61 (0.40–0.92)	0.02

All models used age as the time-scale

[a]Adjusted for BMI, stroke, anti-hypertensive, anti-diabetic, and lipid-lowering drug intake

[b]Adjusted for age, education level, BMI, stroke, anti-hypertensive, anti-diabetic and lipid-lowering drug intake

Table 3 Total life expectancy (LE), dementia-free life expectancy (DemFreeLE) and life expectancy with dementia (DemLE) for selected ages, according to population

Age	1990s population			2000s population		
	Total LE	DemFreeLE	DemLE	Total LE	DemFreeLE	DemLE
70	15.6 (14.8–16.2)	13.6 (12.9–14.0)	2.0 (1.7–2.5)	18.6 (17.9–19.2)	16.3 (15.6–16.7)	2.3 (2.0–2.7)
75	12.3 (11.7–12.8)	10.2 (9.7–10.6)	2.1 (1.8–2.5)	14.7 (14.0–15.2)	12.4 (11.8–12.7)	2.3 (1.9–2.8)
80	9.4 (8.9–9.9)	7.4 (6.9–7.9)	2.0 (1.7–2.4)	11.2 (10.6–11.6)	8.9 (8.5–9.3)	2.3 (1.9–2.7)
85	7.1 (6.5–7.6)	5.3 (4.8–5.8)	1.8 (1.4–2.2)	8.4 (7.8–9.0)	6.4 (6.0–6.9)	2.0 (1.6–2.5)
90	5.2 (4.6–5.8)	3.8 (3.4–4.3)	1.4 (1.0–1.8)	6.0 (5.5–6.4)	4.5 (4.1–5.0)	1.5 (1.1–1.9)

between the 1990s population and the 2000s population, while it seems that the DemLE only slightly increased between the two populations, especially for women and individuals without diploma. Taking into account the age, gender, and diploma distributions in the two populations, the mean increase in total LE and DemFreeLE was 2.5 years (13.3 y vs 15.8 y) and 2.2 years (11.3 y vs 13.5 y), respectively, with thus a 0.3 years increase in DemLE. This increase in total LE and DemFreeLE was found in both men and women with and without a diploma (supplementary tables 2 and 3). However, this increase was lower for older men and more highly educated subjects. For example, at the age of 75 years, the total LE increased by 3.1 years (2.6–3.7) for men without a diploma and by 1.3 years (1.2–1.7) for men with a diploma (Fig. 1). For women of the same age, the total LE increased by 4.6 years (3.9–5.1) for women without a diploma and by 2.6 years (2.3–3.1) for those with a diploma. At the same age, the increase in DemFreeLE in the 2000s population compared to the 1990s population was higher in less educated participants (for instance, for men 75 years old, 2.5 (2.2–3.1) additional years were lived free of dementia for the subjects without a diploma versus 1.3 (1.0–1.6) years for those with a diploma). Consequently, given this differential increase according to education, in the 2000s population, total LE was no longer higher among those with a diploma compared to those without one; only DemFreeLE was higher in highly educated women (Fig. 1). For DemLE, the increase at age 75 was 0.5 years (0.2–0.9) for men without a diploma, while it remained stable for men with a diploma (0.1 y (0.0–0.2). For women of the same age, DemLE increased by 1.3 years (0.6–1.7) for women without a diploma and by 0.6 years (0.3–0.8) for those with a diploma. An increase in DemLE was mostly found for women 85 y.o. or less and for men without diploma (supplementary tables 2 and 3).

Table 4 shows the survival of participants with dementia (i.e., the average number of years an individual who has attained the state of dementia is expected to live with the disease) for both populations: first globally, and then according to gender and educational level. Survival tends to be higher in women (compared to men) and in participants without a diploma (compared to those with a diploma). In total, except for the youngest subjects

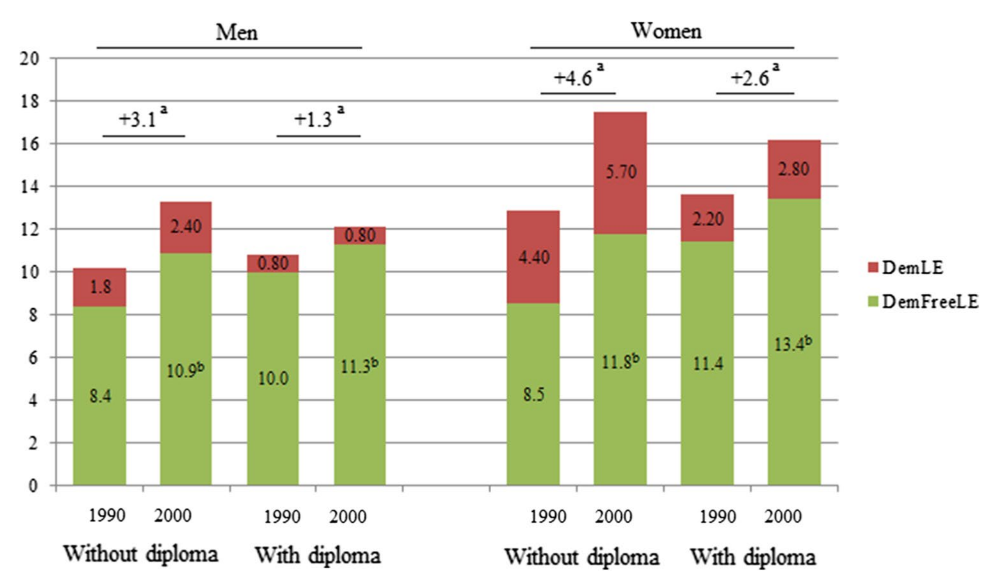

Fig. 1 Life expectancy with and without dementia in years at age 75 between the two populations according to gender and educational level (DemFreeLE, dementia-free life expectancy, DemLE, life expectancy with dementia, Total LE, DemFreeLE + DemLE). [a]Significant increase ($p < 0.05$) in total LE in the 2000's population compared to the 1990' one. [b]Significant increase ($p < 0.05$) in DemFreeLE in the 2000's population compared to the 1990' one

Table 4 Survival after dementia diagnosis in years for selected ages according to generation, gender and education

	Survival with dementia	
	1990s population	2000s population
Overall		
70	7.8 (4.8–10.6)	7.6 (4.8–11.3)
75	6.0 (4.6–7.8)	6.7 (5.1–8.5)
80	4.8 (3.9–5.9)	6.2 (5.1–7.4)
85	3.9 (3.2–4.9)	5.7 (4.7–7.0)
90	3.3 (2.6–4.3)	4.8 (3.9–5.8)
Men without a diploma		
70	7.3 (4.6–10.9)	8.0 (4.8–12.7)
75	5.7 (3.7–9.0)	6.4 (4.3–10.5)
80	4.5 (3.0–8.0)	5.4 (3.6–9.0)
85	3.5 (2.3–6.6)	4.7 (3.1–7.9)
90	2.8 (1.8–5.4)	4.0 (2.6–6.3)
Men with a diploma		
70	5.1 (2.6–8.4)	4.9 (2.8–8.0)
75	3.8 (2.5–6.0)	3.7 (2.7–5.4)
80	3.0 (2.1–4.7)	3.1 (2.4–4.5)
85	2.3 (1.6–3.7)	2.7 (1.9–4.2)
90	1.8 (1.3–3.2)	2.4 (1.6–3.9)
Women without a diploma		
70	10.4 (6.4–13.5)	15.1 (9.6–20.5)
75	8.3 (6.0–11.2)	12.6 (8.7–17.3)
80	6.7 (5.1–9.5)	10.6 (7.6–14.5)
85	5.4 (4.2–7.8)	8.6 (6.6–11.2)
90	4.3 (3.4–6.2)	6.3 (5.3–7.7)
Women with a diploma		
70	7.4 (3.3–11.1)	10.3 (6.4–13.9)
75	5.8 (3.7–8.3)	8.4 (6.0–11.2)
80	4.5 (3.3–6.1)	7.1 (5.5–9.3)
85	3.6 (2.8–4.9)	6.1 (4.8–7.7)
90	2.9 (2.1–3.9)	4.9 (3.8–6.1)

(< 75 years old), survival with dementia showed an increase between the two populations (mean increase in survival: + 1.3 y), mostly driven by an increase among women with and without a diploma. No evolution of men's survival was found.

Discussion

This work has evidenced a decrease in mortality without dementia for men and women between the 1990s and the 2000s and a decrease in mortality with dementia for women only. On the one hand, both total life expectancy and dementia-free life expectancy have increased between the 1990s and the 2000s (total LE + 2.5 and DemFreeLE + 2.2). These increases were lower in participants of increasing age and higher in women and less educated subjects. On the other hand, life expectancy with dementia has only slightly increased (DemLE + 0.3), and survival with dementia has increased, particularly beginning at age 75 (mean increase + 1.3). This increased survival was observed for women only, which is concordant with the decrease in dementia mortality for women. These results might be in favour of a compression of morbidity, at least for men with diploma.

Only a few studies have investigated mortality trends according to dementia status, yielding mixed results. In line with our results, a Swedish study from Stockholm showed a significant decrease in total mortality and mortality without dementia for both genders and a significant decrease in mortality with dementia for women only [9]. However, a rural Swedish study found a significant decrease in total mortality for men only, and the decrease in mortality by dementia status was not significant [10]. The sample size was, however, small in the latter study (between 300 and 400 subjects). Then, a study using insurance data found a stable mortality without dementia for both men and women and a significant increase in dementia mortality for women only [11]. However, dementia ascertained by an administrative database is highly dependent on care access, which can lead to biased trends. A US study reported an increased risk of death between generations with moderate/severe cognitive impairment, which became non-significant after adjustment [20]. More recently, the results from the Framingham Heart Study (FHS) showed an increased age at dementia onset with a decrease in the number of years lived with dementia; yet, the adjusted 5-year mortality risk non-significantly decreased in persons with dementia [12]. So far, explanations behind these trends are unknown, and only a few studies have investigated factors related to these evolutions. In the FHS, these trends were not related to improvement of education, whereas in the study from Langa and colleagues, education explained the increased mortality. In our results, the risk factors accounted for in the analyses did not truly explain the decrease.

Our findings have evidenced a global increase in total life expectancy, which was associated with an increase in life expectancy without dementia, whereas life expectancy with dementia only slightly increased. However, survival with dementia, i.e., the average number of years an individual who has attained the state of dementia lives, showed an increase for women. Data regarding dementia-free life expectancy in 1990 had already been published by our team for nearly the same geographical area as in the present study: results regarding DemFreeLE were similar to those from our 1990s population, but the total LE was higher [21], and methodological differences may explain this difference. Indeed, prevalence data and not incidence data (as in the present study) were used to provide LE; moreover, mortality statistics from France were applied while we used mortality data from our two populations. The increase in total life expectancy among older individuals has been widely documented [1, 22]. A study based on the CFAS I and II participants showed an increase in life expectancy among adults aged 70 years of 3 years for men and 2.5 years for women between the years 1991 and 2011, with estimates of total LE in line with our results [23]. However, if trends in life expectancy with and without disability have been well documented [23–25], only a few studies have investigated changes in life expectancy according to dementia status between generations. A previous study comparing life expectancy at age 65 between 2006/2007 and 2009/2010 failed to evidence significant changes in total LE or DemFreeLE but reported a significant decrease in LE with dementia for women [11]. However, the time period may have been too short to evidence any trends; moreover, data are from an administrative database, and potential bias is inherent to such data. More recently, the results from the Health and Retirement study have reported an increase in life expectancy with good cognition at age 65 for both genders between 2000 and 2010, with similar conclusions regarding effect of education, also suggesting a compression of cognitive morbidity [26, 27]. Another American study reported a decrease in the proportion of life spent without dementia for men but an increase in that for women between a 1971 and a 1980 cohort, related to a decrease in mortality for men only [28]. Indeed, they did not show any improvement in total LE for women but a small decrease in LE with dementia. Differences between countries may be due to inequalities in life expectancy, especially related to an important difference between men and women in France.

Trends regarding survival with dementia have been poorly investigated. The results from the FHS showed a trend towards fewer years lived with dementia over time [12]. In our study, we have evidenced increased survival with dementia for women only. Globally, women experienced higher life expectancies with more time spent free of dementia but also higher survival with dementia than men. These results are in line with those of previous studies [21]. Moreover, individuals with high educational levels spent more years free of dementia and fewer years with dementia than individuals with low educational levels, as previously shown in other studies [29, 30]. A recent literature review reported shorter survival times compared to our study, with differences between men and women for older ages only [31]. This might be due to the larger difference between men and women survival in France, with a high life expectancy for women. Moreover, the use of prevalent cases may lower survival times.

The main limit of this work is the low response rate of the 3C study, leading to the selection of potentially healthier participants, which might have overestimated the trends evidenced. However, sensitivity analyses showed that an increase of 50% of both the risk of dementia and the risk of death without dementia among refusals would be necessary to balance the decrease of dementia mortality without dementia for men, and would only lower the decrease of mortality with or without dementia in women in the 2000s population. Moreover, the statistical model used for the analyses assumes risk proportionality for adjustment factors. However, this assumption cannot be verified. Thus, in the analyses estimating the HRs of mortality according to the generation (both populations pooled), we have decided to stratify analyses by gender to avoid this assumption. In the models computing life expectancies, analyses were realized for the two populations separately and were adjusted for gender and education to limit the loss of statistical power.

This work has several strengths. It relies on the comparison of two large independent populations 10 years apart, followed for 10 years with identical designs and procedures of data collection. To limit the impact of diagnosis evolution, we assessed dementia based on an algorithmic approach. The effects of several risk factors have been investigated to evaluate if some of these factors could explain the trends. Furthermore, life expectancies have been calculated over a ten-year period, whereas most previous life expectancies have been estimated using cross-sectional data [26–29].

The continuous increase in total LE is good news given that the extra years gained are not lived in poor health, especially with dementia. Particularly in the context of the ageing of the baby-boomer generations, monitoring trends of the evolution of indicators such as life expectancy with and without dementia is crucial for industrialized societies. The increase in life expectancy free of dementia is thus promising; however, the decreased mortality with dementia observed in women leads to their longer survival with dementia.

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Compliance with ethical standards

Conflict of interest Leslie Grasset, Karine Pérès, Pierre Joly, Camille Sabathé, Alexandra Foubert-Samier and Catherine Helmer declare that they have no conflict of interest. Jean François Dartigues has received research Grants from IPSEN and Roche, outside the submitted work.

Informed consent Informed consent was obtained from all individual participants included in the study.

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