Title: The influence of socioeconomic deprivation on dementia mortality, age at death and quality of diagnosis: a nationwide death records study in England and Wales 2001-2017

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Key terms: Alzheimer's; dementia; deprivation; socioeconomic status; mortality; age at death; diagnosis

Abstract

Background. Socioeconomic deprivation may be an important determinant of dementia risk, mortality, and access to diagnostic services. Premature mortality from other causes and under-representation of deprived individuals in research may lead to this effect being overlooked.

Methods. We obtained Office of National Statistics (ONS) mortality data for England and Wales from 2001 to 2017, stratified by age, diagnosis code and UK Index of Multiple Deprivation (IMD) decile. We used standardised mortality ratios (SMR) and a Poisson model to compare likelihood of dying from dementia in each IMD decile. We also examined the associations of deprivation with age at death from dementia, and with likelihood of receiving a diagnosis of unspecified dementia.

Findings. Risk of dying from dementia was higher in more deprived deciles (Mean SMR [95%CI] in decile 1: 0.528 [0.506 to 0.550], decile 10: 0.369 [0.338 to 0.400]). In 2017, 14,837 excess dementia deaths were attributable to deprivation (21.5% of all dementia deaths that year). There were dose-response associations of deprivation with likelihood of being older at death with dementia (odds ratio [95%CI] for decile 10 (least deprived): 1.31 [1.28 to 1.33] relative to decile 1), and with likelihood of receiving a diagnosis of unspecified dementia (odds ratio [95%CI] for decile 10: 0.78 [0.76 to 0.80] relative to decile 1).

Conclusion. Socioeconomic deprivation in England and Wales is associated with increased dementia mortality, younger age at death with dementia, and poorer access to specialist diagnosis. Reducing social inequality may have a role in the prevention of dementia mortality.

Introduction

Persistent and widening socioeconomic inequality in the United Kingdom is associated with negative health outcomes including excess premature mortality in those who are more deprived[1]. However, the association of this with dementia mortality across the United Kingdom has not been systematically examined.

Socioeconomic deprivation has previously been shown to be a risk factor for dementia[2-6]. Various factors have been hypothesised to mediate this relationship, including cognitive reserve, education, diet, vascular risk factors, stress and access to healthcare[7]. Deprivation is closely linked to education, which has been more widely studied as a risk factor for dementia, but some evidence suggests that wealth and area-based indices of deprivation may be more important than education when all are taken into account[8, 9]. Deprivation has also been associated with earlier death from dementia and with reduced access to good dementia care[10, 11].

There are obstacles to examining the effect of deprivation on dementia outcomes, and its importance as a risk factor is therefore often overlooked[8]. Cohort studies tend to under-represent more deprived participants, while in population studies survival bias and incomplete ascertainment of cases in more deprived groups due to healthcare inequalities may lead to underestimation of the influence of deprivation[12-16].

We used nationwide death certificate data from all of England and Wales during a 17-year period from 2001 to 2017. Deprivation was measured using the Index of Multiple Deprivation (IMD). The primary aim of the study was to test the hypothesis that age-standardised mortality from dementia would be higher in more deprived deciles, and that this effect would become greater over time due to disproportionate improvements in ascertainment in the more deprived deciles. Furthermore, we hypothesised that those dying of dementia would be younger on average in more deprived deciles. Finally, we hypothesised that more deprived

deciles would be more likely to have an unspecified dementia diagnosis (as opposed to any

specified dementia syndrome), reflecting poorer access to specialist diagnostic services[17].

Methods

Data Selection

Mortality data were obtained from the Office for National Statistics (ONS). A search of dementia deaths was conducted to obtain data between 2001-2017 (from the start of ICD-10 coding to the latest year available at the time of data access), for those aged 65 and over in England and Wales where dementia was listed as a cause of death according to ONS coding algorithms (either listed as an underlying cause of death or mentioned on the death certificate where the cause of death was listed as chest infection or aspiration pneumonia). The lower age limit of 65 was chosen because this is the standard age used to dichotomise early and late onset dementia. Below this age, dementia is much more likely to be genetic in aetiology, less likely to be influenced by life course factors, and the numbers of deaths are very small resulting in imprecise mortality ratio estimates. The number of deaths were split by age group (65-69; 70-74; 75-79; 80-84; 85-89; 90+), Index of Multiple Deprivation (IMD) decile (1: most deprived), year and specific dementia type at death (Alzheimer's disease; Unspecified dementia; Vascular dementia; Other specified dementia), according to the ICD-10 code. A full list of ICD-10 codes and their diagnostic groupings is available in Supplementary Table 1. The population size for each age band and IMD decile, per year, was also obtained from the ONS. We were thus able to partly mitigate the influence of premature mortality from other causes by adjusting for surviving population size within each IMD decile in each year.

Defining deprivation

Deprivation was measured using the UK Index of Multiple Deprivation (IMD). This is an area-based measure of socioeconomic status that ranks every lower-layer super output area (LSOA; a small geographical area with on average 1500 inhabitants) in England and Wales, taking into account seven domains of deprivation: income, employment, education, health, crime, barriers to housing and services, and living environment. Each LSOA is then assigned to a national decile of deprivation.

Statistical Methods

Association of deprivation with dementia mortality

Population size was aggregated across age bands and the number of deaths across age bands and dementia type. Mortality rates were calculated for each IMD-year level. IMD decile 1 (most deprived decile) in 2017 was used as the reference category and the standardised mortality ratio (SMR) was calculated for all levels. As we wished to model the effect of IMD on SMR over time, linear models are not appropriate for this data, given the non-linear relationship between time and SMR for each IMD decile. Instead we used a generalised additive model (GAM), which uses smoothing functions to model non-linear relationships. In our case we modelled year as a smooth term. We calculated excess deaths attributable to deprivation in 2017 by determining the expected deaths in each IMD decile based on the SMR for decile 10, and then subtracting this from the observed number of deaths. We additionally fitted a Poisson model with number of deaths as the response, IMD decile and age group as independent variables, and person-years as an offset in order to model the association of deprivation with incident risk of dying from dementia during the 17 year period.

Association of deprivation with age at death

In order to examine the effect of IMD on age at death from dementia, the number of deaths due to dementia was aggregated across year and dementia type, as were the population sizes within these strata. We used an ordinal logistic regression model to determine the effect of IMD on age at death with dementia, expressed as the cumulative odds of being in any older age group at death. For each decile, the percentage of deaths from that decile that occurred in each age-group was also calculated.

Association of deprivation with dementia diagnosis

In order to examine the effect of IMD on whether the subtype of dementia at death was specified or not (a proxy for access to appropriate specialist care[17], the number of deaths

was aggregated across age and year, and categorised as unspecified dementia or any specified dementia. We used a logistic regression model to determine the effect of deprivation on the odds of having a diagnosis of unspecified dementia versus any specified dementia diagnosis.

Analyses were conducted using R (version 3.6.2).

Data Availability

All data are publicly available from the Office of National Statistics: https://www.ons.gov.uk

Results

There were 578,623 recorded deaths due to dementia from 2001-2017 in England and Wales, with an overall mortality rate of 3.69 per 1000 people over the age of 65. 351,438 (61%) of dementia deaths were recorded as unspecified dementia, whereas only 137,477 (24%) deaths were recorded as being due to Alzheimer's disease. The total number of deaths recorded by year, deprivation decile, dementia type and age-group are available in Supplementary Table 2.

Association of deprivation with dementia mortality

In general, the SMR increased over time, with higher standardised mortality in more deprived deciles (Figure 1). There was a marked increase in mortality between 2010 and 2011 (median increase in SMR=0.19 across deprivation deciles, range 0.16 to 0.24) and a smaller increase seen between 2014 and 2015 (median increase in SMR=0.12, range 0.09 to 0.16). These coincided with ONS recoding of vascular dementia (2010-2011)[18] and incentivisation of dementia diagnosis recording in primary care (2014-15)[19]. A GAM was implemented to assess the trend of SMR across deprivation, by smoothing the non-linear relationship seen between year and SMR (Table 1a). This showed that deprivation deciles 4-10 have a reduced SMR compared to deprivation decile 1, after accounting for year. There was stronger statistical evidence of a difference in mortality as the deciles increased, with the least deprived having the lowest mean SMR (0.369, 95% CI: 0.338 to 0.400); a decrease of 0.159 from decile 1; $p < 0.001$). In 2017 there were 14,837 excess dementia deaths attributable to deprivation (95% CI 13,662 to 16,011). This represented 21.5% of all recorded dementia deaths that year (95% CI 19.8% to 23.2%). Results of the Poisson model were consistent with the SMR analysis and are shown in Table 2. Decreasing deprivation was associated with progressively declining incident risk ratios for dementia mortality (risk ratio for least deprived decile 0.75 [95% CI 0.74 to 0.76]).

Association of deprivation with age at death

An ordinal logistic regression analysis was implemented to investigate the influence of deprivation on the age at death with dementia (Table 1b). This indicated that as deprivation decreases, then the odds of dying at an older age increase. For example, the least deprived decile had the greatest OR of 1.31 (95% CI: 1.28 to 1.33), indicating that the odds of dying at an older age is 31% greater than for the most deprived decile.

Amongst each deprivation decile the proportion of patients dying in each age category was examined (Figure 2). This showed that a greater proportion of the most deprived deciles died in the younger age groups (e.g. 1.6% of deaths in the most deprived decile occurred in the 65-69 age group, compared to 1.3% of the least deprived [p<0.001]). This relationship persisted up until the 80-84 age group. A higher proportion of dementia deaths in the least deprived deciles occurred over the age of 90 (38.8% of the least deprived decile compared to 33.1% of the most deprived decile).

Association of deprivation with dementia diagnosis

Decreasing deprivation was associated with a dose-dependent decrease in the odds of having an unspecified dementia diagnosis compared to any specified aetiology (Table 1c). For example, people from the most affluent areas had 22% lower odds of having an unspecified diagnosis at death (95% CI: 20 to 24%), compared to those in the poorest areas.

Discussion

In this study, using routinely collected death certificate diagnoses in England and Wales between 2001 to 2017, we demonstrate that greater socioeconomic deprivation is associated with higher dementia mortality and this effect appears to be increasing over time. These findings add to mounting evidence that socioeconomic status is an important determinant of dementia risk[2-6]. Although a direct causal relationship between socioeconomic status and dementia has yet to be established, stratification of other dementia risk factors within more deprived groups would still suggest that deprivation could be a major target in public health approaches aimed at reducing the population burden of dementia.

The steadily rising dementia SMR evident in these data despite falling age-specific dementia incidence during the same time period is likely to be due to improving ascertainment[16]. Particularly large year-on-year increases in SMR coincided with known improvements in ascertainment related to recoding of vascular dementia by ONS (2011) and incentivisation of dementia diagnosis recording in primary care (2015)[18, 19].

We also found that disparities in dementia mortality according to deprivation increased steadily over this time period. This could be because of disproportionately poor ascertainment in more deprived populations in earlier years, as a result of which improving ascertainment has begun to reveal the true scale of the effect. Of greater public health concern would be the alternative explanation that persistent and widening inequality in England and Wales is having an increasingly deleterious effect on brain health. Given previous findings of increasing excess mortality according to deprivation for other diseases in England and Wales, it is likely that the increasing disparities are due to a combination of both improved ascertainment and widening inequality[1].

Being more deprived was associated with younger age at death in those dying from dementia. This supports the view that the excess in premature mortality found previously in

UK death certificate data is partly due to dementia deaths[1]. It also supports previous findings that lower socioeconomic status is associated with diagnosis of dementia at a younger age and earlier mortality from dementia[10, 20].

The finding that more deprived deciles were more likely to receive a diagnosis of unspecified dementia implies that these groups had poorer access to specialist diagnostic services[17]. This is consistent with previous evidence showing that more deprived patients access services later, and are less likely to be prescribed anti-dementia drugs, implying that they are receiving lower quality care[11, 21]. These findings raise important challenges for the design of memory clinic services in order to ensure equitable access, diagnosis and treatment. From a clinical perspective, it is likely that poorer quality of diagnosis in more deprived patients means that they are being disadvantaged in terms of prognostication, counselling, planning of future care, access to appropriate symptomatic treatments and opportunities to participate in research. The under-representation of participants of low socioeconomic status is a key challenge for the validity and generalisability of dementia research including clinical trials, and ensuring more timely and accurate diagnosis would be an important first step to mitigate this.

The strengths of this work are that it is a large nationwide study that is perfectly representative of the population. Moreover, the ability to adjust for the surviving population size in each deprivation decile and age group made it possible to mitigate against survival effects to some extent, because while those in more deprived deciles are likely to die prematurely, their risk of dying from dementia is higher in those surviving. This is evident when comparing the trends for numbers of dementia deaths in each IMD decile (which are highest in decile 6, and similar in deciles 1 and 10; see Supplementary Table 2) to the trend of SMR after adjusting for surviving population size, which is highest in more deprived deciles. These aspects are likely to explain why we found important effects of deprivation on mortality and age at death when these were not previously detected in a UK population study over a similar time period[13].

There are important limitations to the current study. Chief among these is the ascertainment of dementia through coding in death certificates. This is likely to have high positive predictive value for all-cause dementia, but lower positive predictive value for specific dementia subtypes, and is likely to lead to incomplete ascertainment of dementia cases[22]. It is noteworthy, however, that improved ascertainment over time appears to have enhanced the size of the effect, suggesting that incomplete ascertainment would tend to bias towards the null in this study. It is possible that the effect of deprivation on quality of diagnosis is partly due to variation in the standard of death certificate completion rather than diagnosis during life. Although we were able to adjust for surviving population size, this does not completely correct for survival bias. In particular, those with premature mortality from other causes are likely to have comorbidities that increase dementia risk, and would therefore be more likely to develop dementia in later years than the background population. It is possible therefore that even in this very comprehensive dataset, the effect of deprivation is underestimated. Another major limitation is the use of an area-based summary measure of deprivation. This does not allow any inferences to be made about which aspects of deprivation are mediating the effects. In particular, it is possible that deprivation here is simply serving as a proxy for lower educational attainment, which is known to be an important determinant of dementia risk[23]. However, recent evidence suggests that the reverse may be true, i.e. that education acts as a proxy for deprivation more generally in studies on dementia risk [9, 24, 25]. Moreover, the evidence for an influence of low education principally relates to having no secondary level education or being illiterate[8, 26]. Secondary education has been compulsory in England and Wales since the Fisher Act of 1918 and literacy rates in the United Kingdom are around 99%, hence it is unlikely that the large effects seen here could be attributable to a very small proportion of the population who were illiterate or had no secondary education. Finally, with these data, we are unable to account for changing socioeconomic status over time, or for internal migration, and therefore we are unable to assess when in the life course deprivation is mediating the observed effects. This may be important, as previous work has suggested

both cumulative effects across the life course and differential effects at different ages, with cognitive decline most strongly linked to wealth in later life[27, 28].

Future work should focus on addressing the issues of under-representation and survival bias in well-phenotyped cohorts that allow for more detailed analysis of the factors mediating the influence of deprivation on risk of dementia. Important outstanding questions include clarifying which aspects of deprivation are having the most important effects, when in the life course these effects are occurring, and how the effects are mediated. Whereas some studies have suggested that cognitive reserve is the most important mediator of increased dementia risk[29], others have suggested that the effect is mediated by other modifiable risk factors, especially vascular risk[24]. Other suggested links between socioeconomic status and dementia outcomes such as stress, diet and air pollution have not been comprehensively evaluated as mediators[7]. A more complete understanding of these issues will allow for the design of public health interventions that target the most deleterious components of deprivation at the appropriate time in life with a view to preventing future dementia.

Conclusions

Socioeconomic deprivation in England and Wales is associated with higher mortality from dementia, younger age at death with dementia and poorer quality of diagnosis. This suggests that political failures to combat persistent and widening socioeconomic inequality in the UK might be contributing to the rising tide of dementia. In the context of enormous and growing societal costs of dementia, and the failure of disease modifying therapies, there should be added impetus to address deprivation with a view to promoting lifelong brain health and potentially preventing dementia.

Contributors

AN and CRM conceived the idea for the study. MJ, GNKA and CRM analysed the data. GNKA, TK, EP and CRM performed a review of existing literature. MJ, GNKA and CRM drafted the manuscript. AN, RD and AJN reviewed the manuscript and contributed intellectual content.

Competing Interests

References

1.   Lewer D, Jayatunga W, Aldridge RW, Edge C, Marmot M, Story A, et al. Premature mortality attributable to socioeconomic inequality in England between 2003 and 2018: an observational study. Lancet Public Health. 2020;5(1):e33-41.

2.   Rait G, Walters K, Bottomley C, Petersen I, Iliffe S, Nazareth I. Survival of People With Clinical Diagnosis of Dementia in Primary Care: Cohort Study. BMJ (Clinical research ed). 2010;341.

3.   Yaffe K, Falvey C, Harris TB, Newman A, Satterfield S, Koster A, et al. Effect of socioeconomic disparities on incidence of dementia among biracial older adults: prospective study. BMJ. 3472013.

4.   Bebe A, Siersma V, Kragstrup J, Nielsen A, Møller A, Søndergaard J, et al. The Effect of Economic Assets on Mortality in Patients With Dementia: A Population-Based Cohort Study. Journal of Alzheimer's disease : JAD. 2019;67(4).

5.   Korhonen K, Einiö E, Leinonen T, Tarkiainen L, Martikainen P. Midlife socioeconomic position and old-age dementia mortality: a large prospective register-based study from Finland. BMJ Open. 2020;10(1).

6.   Scazufca M, Almeida O, Menezes P. The Role of Literacy, Occupation and Income in Dementia Prevention: The São Paulo Ageing & Health Study (SPAH). International psychogeriatrics. 2010;22(8).

7.   de Paula França Resende E, Guerra JJL, Miller BL. Health and Socioeconomic Inequities as Contributors to Brain Health. JAMA Neurol. 2019.

8.   Livingston G, Huntley J, Sommerlad A, Ames D, Ballard C, Banerjee S, et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission - The Lancet. 2020.

9.   Cadar D, Lassale C, Davies H, Llewellyn DJ, Batty GD, Steptoe A. Individual and Area-Based Socioeconomic Factors Associated With Dementia Incidence in England: Evidence From a 12-Year Follow-up in the English Longitudinal Study of Ageing. JAMA Psychiatry. 2018;75(7):723-32.

10.   van de Vorst I, Koek H, Stein C, Bots M, Vaartjes I. Socioeconomic Disparities and Mortality After a Diagnosis of Dementia: Results From a Nationwide Registry Linkage Study. American journal of epidemiology. 2016;184(3).

11.   Cooper C, Lodwick R, Walters K, Raine R, Manthorpe J, Iliffe S, et al. Observational Cohort Study: Deprivation and Access to Anti-Dementia Drugs in the UK. Age and ageing. 2016;45(1).

12.   Goodman A, Gatward R. Who are we missing? Area deprivation and survey participation. Eur J Epidemiol. 2008;23(6):379-87.

13.   Vestergaard A, Sampson E, Johnsen S, Petersen I. Social Inequalities in Life Expectancy and Mortality in People With Dementia in the United Kingdom. Alzheimer disease and associated disorders. 2020.

14.   Mayeda E, Tchetgen Tchetgen E, Power M, Weuve J, Jacqmin-Gadda H, Marden J, et al. A Simulation Platform for Quantifying Survival Bias: An Application to Research on Determinants of Cognitive Decline. American journal of epidemiology. 2016;184(5).

15.   Weuve J, Proust-Lima C, Power MC, Gross AL, Hofer SM, Thiébaut R, et al. Guidelines for reporting methodological challenges and evaluating potential bias in dementia research. Alzheimers Dement. 2015;11(9):1098-109.

16.   Wolters FJ, Chibnik LB, Waziry R, Anderson R, Berr C, Beiser A, et al. Twenty-seven-year time trends in dementia incidence in Europe and the United States. 2020.

17.   Drabo E, Barthold D, Joyce G, Ferido P, Chui C, Zissimopoulos J. Longitudinal analysis of dementia diagnosis and specialty care among racially diverse Medicare beneficiaries. Alzheimer's & dementia : the journal of the Alzheimer's Association. 2019;15(11).

18.   Patel V. Deaths registered in England and Wales (series DR) - Office for National Statistics: Office for National Statistics; 2020 [Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsregisteredinenglandandwalesseriesdr/2017.

19.   Lea W. Prime Minister's challenge on dementia: Delivering major improvements in dementia care and research by 2015. Department of Health; 2012.

20.	Ajnakina O, Cadar D, Steptoe A. Interplay Between Socioeconomic Markers and Polygenic Predisposition on Timing of Dementia Diagnosis. Journal of the American Geriatrics Society. 2020.

21.	Moritz D, Petitti D. Association of Education With Reported Age of Onset and Severity of Alzheimer's Disease at Presentation: Implications for the Use of Clinical Samples. American journal of epidemiology. 1993;137(4).

22.	Wilkinson T, Schnier C, Bush K, Rannikmäe K, Henshall DE, Lerpiniere C, et al. Identifying dementia outcomes in UK Biobank: a validation study of primary care, hospital admissions and mortality data. Eur J Epidemiol. 2019;34(6):557-65.

23.	Evans D, Hebert L, Beckett L, Scherr P, Albert M, Chown M, et al. Education and Other Measures of Socioeconomic Status and Risk of Incident Alzheimer Disease in a Defined Population of Older Persons. Archives of neurology. 1997;54(11).

24.	Deckers K, Cadar D, van Boxtel MP, Verhey FR, Steptoe A, Köhler S. Modifiable Risk Factors Explain Socioeconomic Inequalities in Dementia Risk: Evidence from a Population-Based Prospective Cohort Study. J Alzheimers Dis. 2019;71(2):549-57.

25.	Hall K, Gao S, Unverzagt F, Hendrie H. Low Education and Childhood Rural Residence: Risk for Alzheimer's Disease in African Americans. Neurology. 2000;54(1).

26.	Arce Rentería M, Vonk J, Felix G, Avila J, Zahodne L, Dalchand E, et al. Illiteracy, Dementia Risk, and Cognitive Trajectories Among Older Adults With Low Education. Neurology. 2019;93(24).

27.	Zeki Al Hazzouri A, Haan MN, Kalbfleisch JD, Galea S, Lisabeth LD, Aiello AE. Life-Course Socioeconomic Position and Incidence of Dementia and Cognitive Impairment Without Dementia in Older Mexican Americans: Results From the Sacramento Area Latino Study on Aging. Am J Epidemiol. 2011;173(10):1148-58.

28.	Marden JR, Tchetgen Tchetgen EJ, Kawachi I, Glymour MM. Contribution of Socioeconomic Status at 3 Life-Course Periods to Late-Life Memory Function and Decline: Early and Late Predictors of Dementia Risk. Am J Epidemiol. 2017;186(7):805-14.

29.	Fotenos A, Mintun M, Snyder A, Morris J, Buckner R. Brain Volume Decline in Aging: Evidence for a Relation Between Socioeconomic Status, Preclinical Alzheimer Disease, and Reserve. Archives of neurology. 2008;65(1).

Tables

IMD decile:	a) Mean SMR (95% CI)	b) OR of being in an older age group at death (95% CI)	c) OR of 'Unspecified dementia' versus any specified (95% CI)
Most deprived - 1	0.528 (0.506, 0.550)	1	1
2	0.541 (0.510, 0.572)	1.10 (1.08, 1.13)	0.98 (0.95, 1.00)
3	0.531 (0.500, 0.562)	1.13 (1.10, 1.15)	0.97 (0.95, 1.00)
4	0.493 (0.462, 0.524)	1.16 (1.14, 1.19)	0.96 (0.94, 0.99)
5	0.481 (0.450, 0.512)	1.24 (1.22, 1.27)	0.91 (0.89, 0.94)
6	0.480 (0.450, 0.512)	1.27 (1.24, 1.30)	0.87 (0.85, 0.89)
7	0.455 (0.424, 0.486)	1.26 (1.24, 1.29)	0.83 (0.81, 0.85)
8	0.440 (0.409, 0.471)	1.29 (1.26, 1.32)	0.82 (0.80, 0.84)
9	0.425 (0.394, 0.456)	1.28 (1.25, 1.31)	0.81 (0.79, 0.83)
Least deprived - 10	0.369 (0.338, 0.400)	1.31 (1.28, 1.33)	0.78 (0.76, 0.80)

Table 1 **The association of deprivation with dementia mortality, age at death and quality of diagnosis**
The table shows a) standardised mortality ratio for dementia in each IMD decile (averaged across years 2001-2017), b) odds ratios of being in any older age group at time of death from dementia for each IMD decile relative to decile 1 and c) odds ratios of receiving a diagnosis of unspecified dementia in each IMD decile relative to decile 1
CI, confidence interval; IMD, Index of Multiple Deprivation; OR, odds ratio; SMR, standardised mortality ratio

Factor	Incident risk ratio (95% CI) for dementia deaths
Age:	
65-69	1
70-74	3.10 (3.02, 3.18)
75-79	9.71 (9.48, 9.94)
80-84	27.70 (27.08, 28.33)
85-89	70.91 (69.35, 72.50)
90+	170.82 (167.08, 174.64)
IMD decile:	
Most deprived - 1	1
2	0.99 (0.98,1.00)
3	0.97 (0.96, 0.98)
4	0.91 (0.90, 0.92)
5	0.90 (0.89, 0.91)
6	0.91 (0.90, 0.92)
7	0.88 (0.87, 0.89)
8	0.86 (0.85, 0.87)
9	0.84 (0.83, 0.85)
Least deprived - 10	0.75 (0.74, 0.76)

Table 2 **The association of age and deprivation with incident risk of dying from dementia.** *The table shows incident risk ratios for death from dementia derived from the Poisson model with person-years of exposure as the offset.*

CI, confidence interval; IMD, Index of Multiple Deprivation

Figures

*Figure 1: **Standardised Mortality Ratios for IMD deciles over time.***
The figure shows SMRs for each IMD decile for population aged 65 or above in England and Wales, with IMD decile 1 in 2017 as the reference category. Shaded areas represent 95% confidence intervals for SMR estimates.
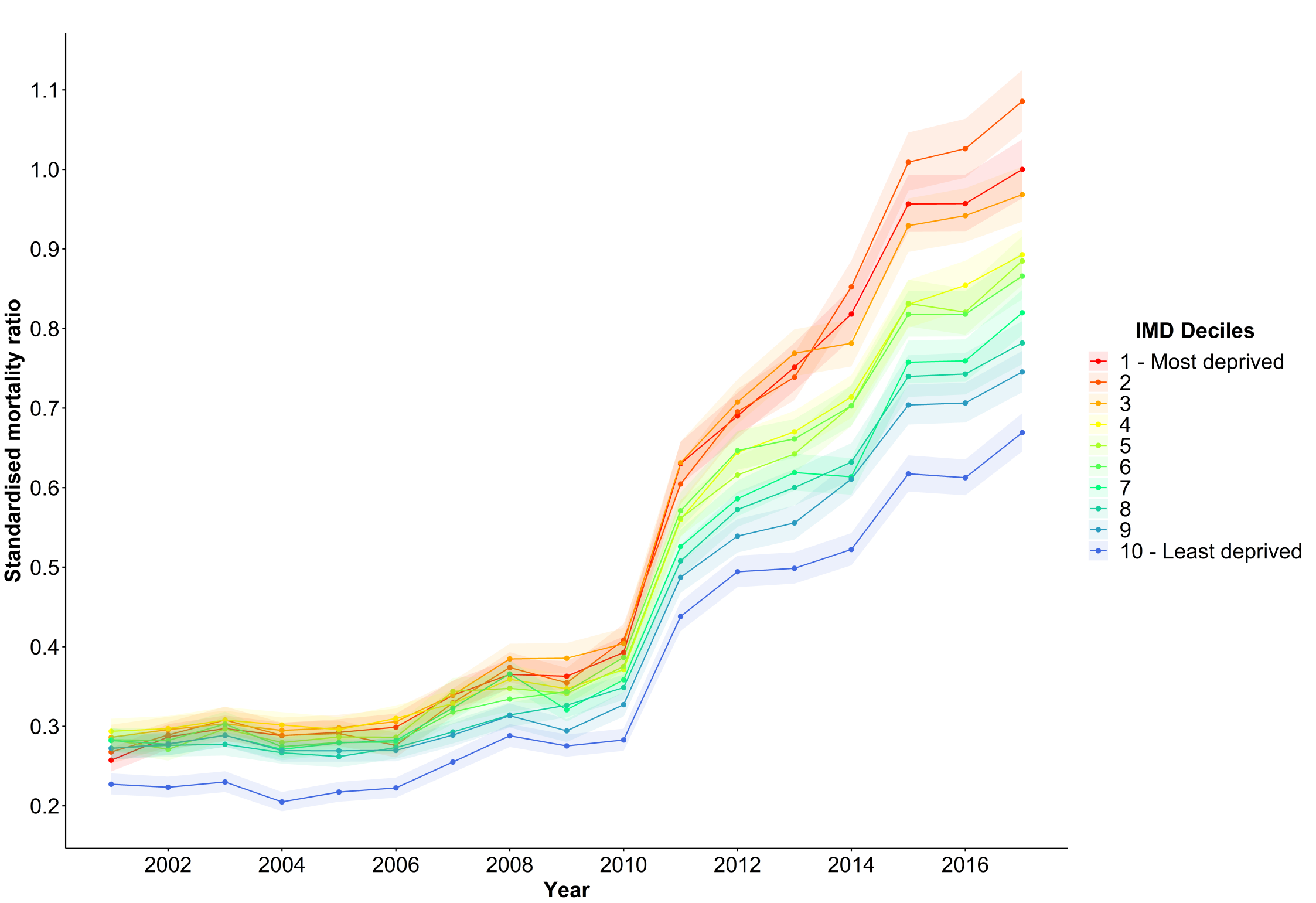*IMD, Index of Multiple Deprivation.*

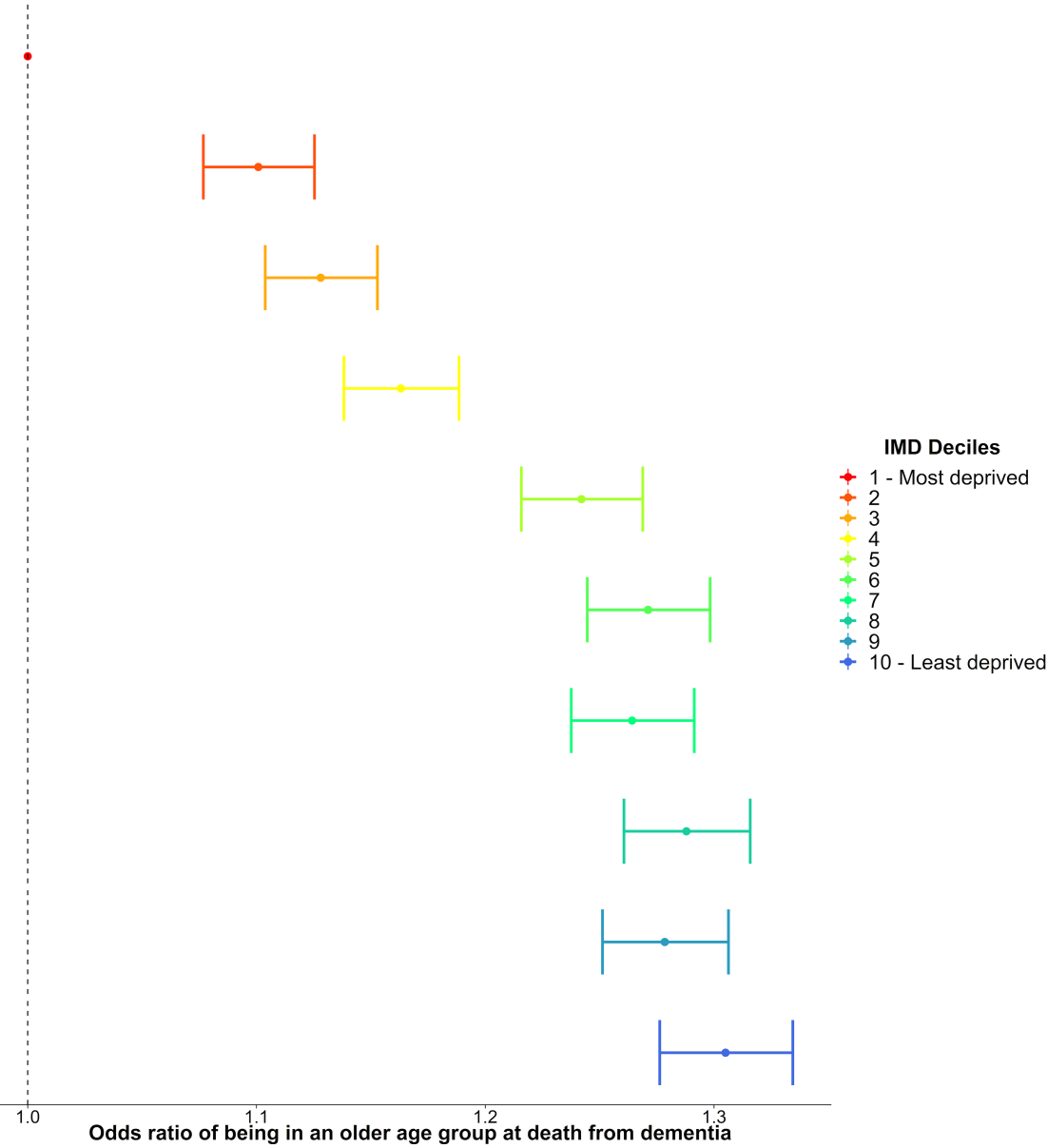*Figure 2: **The association of deprivation with age at death from dementia.***
A: Odds ratios (95% CI) of dying in an older age group according to IMD decile among those who died of dementia aged over 65 in England and Wales between 2001 and 2017.
B: Percentage of dementia deaths within each IMD decile occurring in each age group in England and Wales 2001-2017
IMD, Index of Multiple Deprivation

A

B

IMD Deciles
- 1 - Most deprived
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 - Least deprived

Odds ratio of being in an older age group at death from dementia

Percentage of deaths within IMD decile

Age group

Figures

*Figure 1: **Standardised Mortality Ratios for IMD deciles over time.***
The figure shows SMRs for each IMD decile for population aged 65 or above in England and Wales, with IMD decile 1 in 2017 as the reference category. Shaded areas represent 95% confidence intervals for SMR estimates.
IMD, Index of Multiple Deprivation.

*Figure 2: **The association of deprivation with age at death from dementia.***
A: Odds ratios (95% CI) of dying in an older age group according to IMD decile among those who died of dementia aged over 65 in England and Wales between 2001 and 2017.
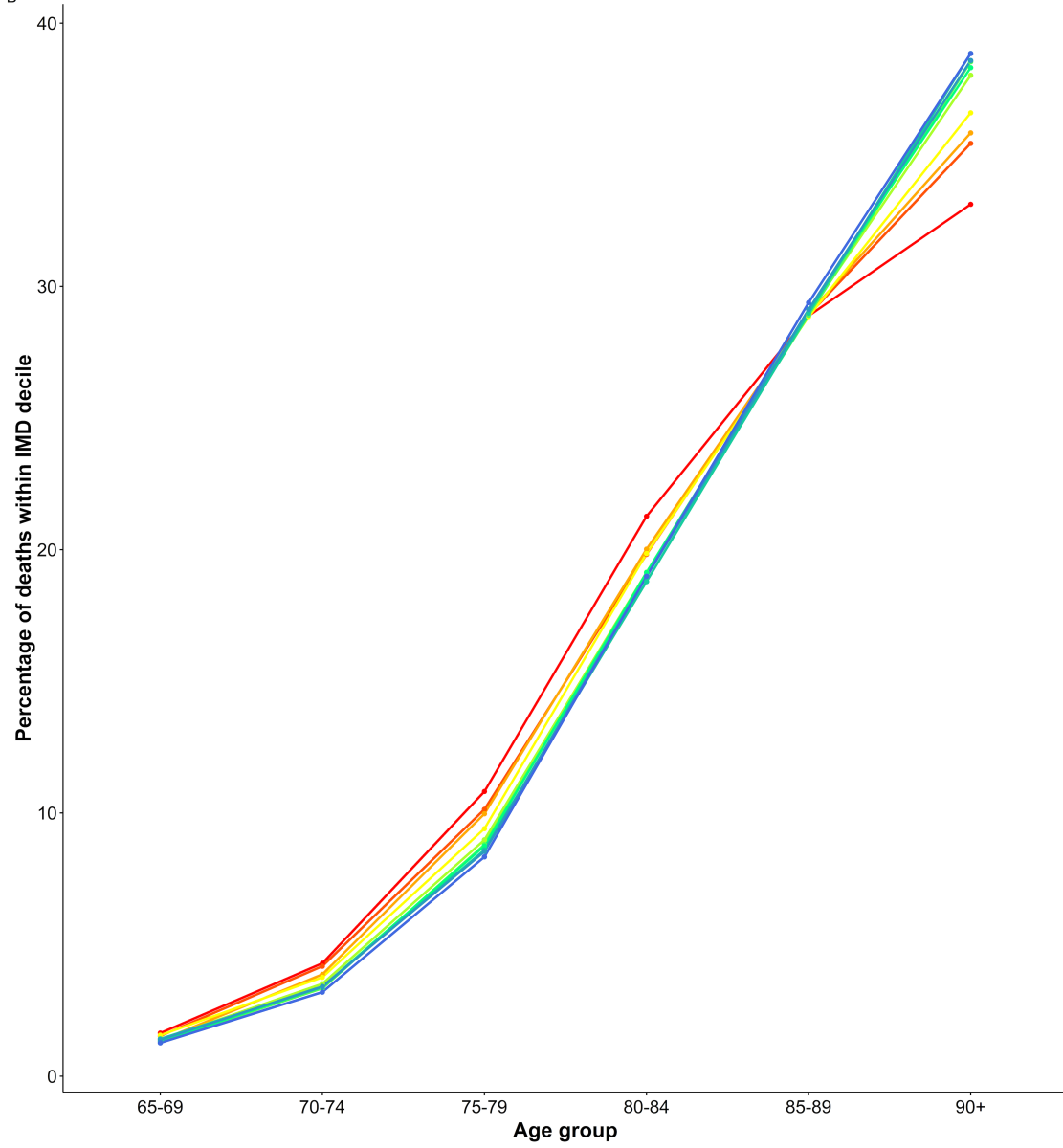*B: Percentage of dementia deaths within each IMD decile occurring in each age group in England and Wales 2001-2017*
IMD, Index of Multiple Deprivation

Supplementary Table 1: ICD 10 codes and diagnostic groupings

ONS coding	Description of coding	ICD-10 coding	Description of coding
F01	Vascular dementia	F01.0	Vascular dementia of acute onset
		F01.1	Multi-infarct dementia
		F01.2	Subcortical vascular dementia
		F01.3	Mixed cortical and subcortical vascular dementia
		F01.8	Other vascular dementia
		F01.9	Vascular dementia, unspecified
F03	Unspecified dementia	F03	Unspecified dementia
G30	Alzheimer's disease	F00.0/G30.0	Dementia in Alzheimer disease with early onset
		F00.1/G30.1	Dementia in Alzheimer disease with late onset
		F00.2/G30.8	Dementia in Alzheimer disease, atypical or mixed type
		F00.9/G30.9	Dementia in Alzheimer disease, unspecified
G31	Other degenerative diseases of nervous system, not elsewhere classified	F02.0	Dementia in Pick disease
		F02.1	Dementia in Creutzfeldt-Jakob disease
		F02.2	Dementia in Huntington disease
		F02.3	Dementia in Parkinson disease
		F02.4	Dementia in human immunodeficiency virus [HIV] disease
		F02.8	Dementia in other specified diseases classified elsewhere
		G31.0	Circumscribed brain atrophy
		G31.1	Senile degeneration of brain, not elsewhere classified
		G31.2	Degeneration of nervous system due to alcohol
		G31.8	Other specified degenerative diseases of nervous system
		G31.9	Degenerative disease of nervous system, unspecified

The table shows ICD 10 diagnostic codes for dementia, along with their grouping by ONS into the broader diagnostic categories used in the analysis.

Supplementary Table 2: Numbers of dementia deaths by year, IMD decile, diagnostic category and age group in England and Wales 2001-2017

a) Year	
2001	17,292
2002	17,682
2003	18,577
2004	17,622
2005	17,939
2006	18,217
2007	20,667
2008	22,857
2009	22,597
2010	25,090
2011	38,460
2012	44,719
2013	48,088
2014	52,464
2015	62,935
2016	64,306
2017	**69,111**

b) IMD decile	
1	49,481
2	53,306
3	56,676
4	57,972
5	61,589
6	**65,045**
7	62,838
8	60,936

9	59,391
10	51,389
c) Dementia Type	
Vascular Dementia (F01)	77,165
Unspecified Dementia (F03)	**351,438**
Mild Cognitive impairment (F06.7)	37
Alzheimer's disease (G30)	137,477
Other degenerative diseases of nervous system, not elsewhere classified (G31)	12,506

d) Age-group	
65-69	8,160
70-74	20,888
75-79	53,174
80-84	112,667
85-89	167,845
90+	**215,889**

The table shows the distribution of total number of dementia deaths recorded across the four categories: a) Year; b) IMD decile; c) diagnostic category; and d) Age-group. The factors with the greatest number of deaths recorded for a given category, is highlighted in bold.