Title: Is the use of the internet in midlife associated with lower dementia incidence? Results from the English longitudinal study of ageing

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Can use of internet from Midlife lower Dementia Incidence? Results from the English Longitudinal Study of Ageing

SPECIAL SECTION DEMENTIA PREVENTION

Abstract:

OBJECTIVES: Dementia is expected to affect one million individuals in the UK by 2025; its prodromal phase may start decades before its clinical onset. The aim of this study is to investigate whether use of internet from 50 years of age is associated with a lower incidence of dementia over a ten-year follow-up. **METHODS**: We analysed data based on 8,238 dementia free (at baseline in 2002-2004) core participants from the English Longitudinal Study of Ageing (ELSA). Information on baseline use of internet was obtained through questionnaires; Dementia casesness was based on participant (or informant) reported physician diagnosed dementia or overall score on the IQCODE questionnaire. Cox proportional hazards regression analysis was used for examining the relationship between digital literacy and incident dementia. **RESULTS:** There were 301 (5.01%) incident dementia cases during the follow-up. After full multivariable adjustment for potential confounding factors, baseline internet use was associated with a 40% reduction in dementia risk assessed between 2006-2012 (HR=0.60 CI: 0.42 to 0.85; $p<0.05$). **CONCLUSION:** This study suggests that use of internet by individuals aged 50 years or older is associated with a reduced risk of dementia. Additional studies are needed to better understand the potential causal mechanisms underlying this association.

Key words: dementia, digital divide, internet, aging, longitudinal studies, prevention

Main text: 4,234 words

Introduction

Between 2005 and 2040 the number of people with dementia around the world is expected to rise from 24.3 million to 81.1 million, with a heavier burden among low and middle income countries.(Ferri et al., 2005) Contrary to the tendency of increasing incidence and prevalence observed in these countries, the incidence of dementia in UK and other developed countries such as the USA seems to be decreasing over the last two decades. A possible explanation for this decline may include health and lifestyle factors, including increased uptake of physical execise and cognitive stimulating activities, such as computer and internet use. (Satizabal et al., 2016; Xavier et al., 2014) Dementia prevalence in the UK may also be decreasing, possibly due to the better primary prevention efforts, like improving physical activity, controlling cardiovascular diseases and better educational attainment.(Matthews et al., 2016; Wu et al., 2016)

Consistent evidence, e.g. based on randomized clinical trials and meta-analyses, shows that various forms of cognitive stimulating activities could delay cognitive decline, even among those with mild cognitive impairment or established Alzheimer's disease.(Mangialasche, Kivipelto, Solomon, & Fratiglioni, 2012a; Ngandu et al., 2015; Ritchie et al., 2010) Although there is still a lack of definitive evidence, it has been estimated that 1 in 3 cases of Alzheimer's disease may be prevented by controlling diabetes, hypertension, obesity, depression, avoiding smoking, alcohol abuse, sedentary lifestyle and by promoting better educational attainment/cognitive activities.(Norton, Matthews, Barnes, Yaffe, & Brayne, 2014)

Alongside demographic ageing, digital literacy is also increasing in the UK, especially among middle-aged and elderly people. Over the past years, there has been a marked increase in computer and internet use in older adulthood; for example, up to 56% of those aged between 65 and 74 years had internet access in 2011("Office Of National Statistics. Internet Access Quarterly Update 2011 Q4.," 2011), which had increased to 71% in 2015.(*Office Of National Statistics. Internet Access Quaterly Update 2015 Q1.*, 2015) This increase in digital literacy, characterised by people's ability to engage in, plan, execute, and evaluate digital actions, including web browsing and exchanging e-mails, is thought to be crucial for dealing

with various everyday tasks nowadays.(Bawden, 2008) Specifically, digital literacy includes the use of diverse digital instruments, such as desktops, laptops, mobile phones and smart TVs when connected to the internet.

It is possible that internet use may reduce the incidence of dementia. Almeida et al. found a 43% reduction in relative risk of dementia for men over 70 years old who use the internet, even after controlling for diabetes, cardiovascular disease, numeracy skills and marital status.(Almeida et al., 2012) Other observational studies also show that internet use and physical activity can help maintain and improve cognition, functional capacity and quality of life (d'Orsi et al., 2014; Marques, Schneider, & D'Orsi, 2016; Xavier et al., 2014) in older adults. Furthermore, internet use by older adults has been associated with healthy diets, engaging in physical activity, less smoking and more participation in cancer screening programs.(Xavier et al., 2013) A recent systematic literature review and meta-analysis showed that computer based interventions may also have a protective effect, even in individuals with established dementia(García-Casal et al., 2016), which underscores the potential benefit of internet use for cognitive health. Many protective factors such as physical activity and blood pressure control seem to be more effective to prevent dementia if they are introduced in younger ages over the life course.(Mangialasche, Kivipelto, Solomon, & Fratiglioni, 2012b)

The aim of this study is to investigate whether email/internet use amid individuals with 50 years or more is associated with lower incidence of dementia over a ten-year follow-up. Specifically, we hypothesised that, compared to individuals who did not report using the internet, those who did would have a lower risk of developing dementia during follow-up.

Methods

Data were obtained from the English Longitudinal Study of Ageing (ELSA), a longitudinal panel study with a representative sample of individuals aged 50 and older residing in England. We used data from 10 years of follow-up from wave 1 (baseline interview in 2002–03), wave 2 (2004–05), wave 3 (2006–07), wave 4 (2008–09), wave 5 (2010–11) to wave 6 (2012-13). Participants with dementia in 2002-03 and/or

2004-05 were excluded in order to assure incident cases. Incident cases of dementia were recorded over ELSA waves 3 (2006-07) to 6 (2012-2013).

Dementia assessment

The dependent variable of this study was dementia, which was defined as a physician diagnosis reported by the participant or an informant in 2006 – 2012 (from 2006-07 onwards). In addition, informants completed the short-form IQ-CODE questionnaire on the cognitive decline of participants who were not able to participate in the ELSA assessment.(Jorm, 1994) This consists of 16 items asking the informant to comment on the ability of the person compared with 10 years ago to perform various functions (e.g. remembering the names of family and friends) with Likert ratings ranging from 'much improved' (five points) to 'much worse'(one point). We used the cut-off point of 3.5 to define dementia, since this has high specificity and good sensitivity.(Harrison et al., 2015) This analysis used a combination of doctor-diagnosed dementia and/or IQCODE scores >=3.5 for identifying dementia cases occurring between 2006-07 and 2012-13. Those diagnosed with dementia in 2002-03 or 2004-05 were excluded to reduce the risk of inverse causality (e.g. those with dementia not engaging in internet use because of dementia symptoms). We also ran sensitivity analyses including these cases from 2004-05 and excluding cases from 2006-07 to further investigate this (see sensitivity analyses).

Use of Internet measurement

The main predictor/exposure variable was use of internet or e-mail assessed according to responses to the statement "I use the internet or email", recorded at 2002-03 and/or 2004-05 as a binary (yes/no) variable. Internet usage was defined by whether a respondent uses the internet and/or email. Those classified as not using the internet reported using it less than once every three months or never.(J Banks, Nazroo, & Steptoe, 2014)

Several potential confounding factors/covariates were included in this analysis, and all were recorded at baseline (2002-03). Among the demographic factors, we included sex (men/women) age in 10 year bands (50 to 59, 60 to 69, 70 to 79 and 80 more years old) and marital status classified into 'married or equivalent' versus 'other' (never married, divorced, separated, and widowed). Among socioeconomic factors, we

included the total household wealth, including financial wealth, the value of any home and other property, the value of business assets, and physical wealth such as artwork and jewelry, and net of debt. Wealth is a robust indicator of socioeconomic circumstances and standard of living in ELSA,(Steptoe, Breeze, Banks, & Nazroo, 2013) and it was divided into quintiles for the purposes of analysis. Education was divided into three categories: 'no formal qualifications', 'intermediate' (equivalent to junior high school, high school and college) and 'higher education' (degree). Ethnicity was not included in these analyses since the number of participants of other ethnic groups different from Caucasians was very small (1.4%) and this was not associated with dementia.

Among health factors, we included self-reported physician diagnoses of coronary heart disease (CHD), cancer, stroke, diabetes, and hypertension. We assessed depressive symptoms using the 8-item Centre for Epidemiologic Studies Depression Scale (CES-D)(Steffick D., 2000) with a cutoff of '6 or more' to define severe depressive symptoms (in a yes/no basis leading to a score from zero to 8 points). Mobility impairment was also included as a covariate, since it might be associated with increased risk of dementia and lower use of internet. Mobility was defined by asking respondents whether they had difficulties with one or more 10 common leg and arm functions (e.g. walking 100 yards, lifting over 10 pounds). Baseline cognitive function was assessed by amalgamating scores from four tests of cognitive ability assessing memory (immediate and delayed recall of word list), semantic verbal fluency (animal naming over one minute), and attention and processing speed (speed and accuracy on a letter cancellation task).(Llewellyn, Lang, Langa, & Huppert, 2008) We computed normalized z scores for each test (mean 0, standard deviation 1) and averaged the normalized scores across tests to produce a single measure.

Statistical analysis

Cox proportional hazards regression models were carried out to estimate hazard ratios (HR) of dementia incidence and 95% confidence intervals, with survival time being measured in months from date of the 2002-03 interview to onset of dementia or to follow-up in 2012-13. The date used to measure the months between 2002-03 and onset of dementia was the midtime point of the wave. For individuals who dropped out of the study without dementia, the most recent wave of data collection was used as the census point.

Univariable descriptive statistics (frequency and percent of baseline characteristics) were carried out, as well as cumulative incidence of dementia estimated by Kaplan Meier failure function and the 95% confidence interval (CI) for the whole sample and by introducing covariates assessed at baseline. Unadjusted (crude) and adjusted (by covariates) hazard ratios (HRs) of dementia with a 95% CI were calculated using Cox regression models. To establish a temporal relationship between the predictor (use of internet) and the outcome (cumulative incidence of dementia), the use of internet was recorded from 2002-03 and 2004-05, and the cumulative incidence of dementia was recorded from 2006-07 to 2012-13. Interactions between sex and use of internet and education and use of internet were tested, as well as analysis stratified by sex.

We fitted three models. Model 1 included demographic (gender, age, marital status); and socioeconomic (education and wealth) variables; and the main predictor (use of internet). In model 2, we added self-rated comorbidities (hypertension, diabetes, stroke, CHD and cancer). In model 3, the final fully adjusted model, we added impaired mobility, depression and baseline cognitive function. Comparisons between models were assessed by likelihood-ratio test (LR).

We carried out three sensitivity analyses with different selected populations. The first addressed the issue of reverse causality by excluding cases diagnosed three years or less from the baseline assessment (e.g. cases of dementia diagnosed at 2002-03, 2004-05 and/or 2006-07), in case marked decline in the months before a diagnosis led to changes in patterns of use of internet.

In the second sensitivity analysis, only those with dementia at 2002-03 were excluded. The outcome was dementia obtained from 2004-05 to 2012-13 and the main predictor was internet use recorded as use of internet before the onset of dementia (yes/no) from 2002-03 to 2012-13. The covariates were those mentioned previously and obtained at baseline (2002-03).

In the third sensitivity analysis we included cases of dementia from 2004-05 to 2012-13 and excluded cases at baseline, we recorded use of internet from 2002-03 to 2010-11 and calculated unadjusted (crude) and adjusted incidence rate ratios (IRRs) of dementia with a 95% confidence interval (CI) through a 2-year lagged Poisson regression models, carried out by generalized estimating equation (GEE), with unstructured within-group correlations and robust variance estimator. To establish a temporal relationship

between the predictor (use of internet) and the outcome (incidence of dementia), the predictor for the preceding time point was modelled against the outcome at the subsequent time point. For example, use of internet at 2002-03 was related to dementia at 2004-05, use of internet at 2004-05 was related to dementia at 2006-07, and so on, in persons free of dementia at baseline. All analyses were performed using Stata version 13 with a p-value of 0.05 indicating significance.

In order to map the associations between the predictors, we performed univariate and multivariate logistic regression analysis with the use of internet as outcome and sociodemographic (sex, age, education, wealth) and comorbidities (depression, cancer, hypertension, cardiovascular disease and stroke) as covariates.

Results

From the initial 11,392 individuals interviewed at 2002-03, n=803 were excluded because of missing information on internet use at 2002-03 and 2004-05. Dementia cases at 2002-03 (n=102) or 2004-05 (n=62) were also excluded; 2,187 individuals were excluded because of missing information on the other variables at baseline. The analytical sample involved 8,238 ELSA participants without dementia at 2002-03 nor at 2004-05, followed up over 10 years (until 2012-13), with complete data to all variables at baseline. Over this time (from 2006-07 to 2012-13) 301 participants were diagnosed with dementia, or had an informant rating above the IQ-code threshold indicative of dementia (see methods).

Table 1 presents the characteristics of the sample at 2002-03 and the incidence of dementia by comparing covariates for those diagnosed with dementia at any wave after 2006-07 and controls (those who did not develop dementia over the follow-up). The majority of the sample was composed by individuals aged 50 to 69 years old, who were women, married, with an intermediate education level. Almost two thirds reported hypertension, one fifth reported coronary heart disease and 15% had depressive symptoms above threshold. The prevalence of self-reported diabetes was almost 7%, cancer was 6% and stroke was 4%. More than 40% had impaired mobility. The internet use was not so frequent at 2002-03 or 2004-05, since only 40% reported it.

The analysis regarding the profile of internet users revealed higher probabilities of using the internet to male, younger, more educated and wealthier ($p<0,05$) and lower probabilities of using the internet to those with comorbidities ($p<0.05$ for all comorbidities except for cancer). In logistic multivariate analysis male, younger age, higher education and higher wealth remained as independent factors associated with use of internet and depressive symptoms was the only comorbidity associated with lower probability of use of internet (data not shown).

The cumulative incidence of dementia over the studied period was 5.01% (CI95%:4.49;5.60). For people aged 60+years old, it was 8.18% (CI95%: 7.31-9.16). It was similar in men and women, and increased with age (almost one third for people aged 80+ years old). The incidence was also higher for people who were at baseline: not married, with no formal education qualification, less wealthy, with hypertension, diabetes, stroke, coronary heart disease, for those with impaired mobility, and for those with more depressive symptoms. The incidence was almost five times lower for those who reported use of internet at 2002-03 and/or or 2004-05, when compared to those who did not.

Table 2 presents the adjusted Cox regression analysis results showing the relationship between use of internet and incident dementia. Three models are shown. In the 1st model, incident dementia was associated with and older age, less education, less wealth and there was a lower risk for married participants. Use of internet was independently associated with a significant reduction in risk of dementia in this model. In the 2nd model, age, wealth, marital status and diabetes were all independently associated with dementia. The use of internet remained significantly associated with lower risk of dementia. In the 3rd and fully adjusted model, the use of internet remained as an independent predictor of dementia, along with age, wealth, depressive symptoms and the cognitive index at baseline. The association was large, with a 40% reduction in hazard risk of dementia for those who used the internet at 2002-03 and/or 2004-05 (HR=0.60 CI: 0.42 to 0.85; $p<0.05$). The magnitude of the association between use of internet and reduced risk of dementia changed very little across the three models. The inclusion of the variable use of internet was significative to the model (LR= 8.67; $p=0.003$). Interactions between sex and use of internet; education and use of internet were nonsignificant. Analysis stratified by sex yielded similar results.

Sensitivity analysis

Results from the 1st sensitivity analysis showed that in the final fully adjusted model participants who reported using the internet at 2002-03 and/or 2004-05 had a 44% lower risk of developing dementia at 2008-09 to 2012-13 (HR=0.56 CI95%: 0.37 to 0.85, p<0.05). (supplementary table 1)

Results from the 2nd sensitivity analysis showed that in the fully adjusted model those who reported previous use of internet had a 58% lower risk of developing dementia at any point in the future (HR=0.42 CI95%:0.31 to 0.57; p<0.001) (supplementary table 2)

Results from the 3rd sensitivity analysis showed that in the fully adjusted final model those who had used the internet in the previous wave had a 43% lower risk of developing dementia in the subsequent wave. (IRR=0.57 CI95%: 0.37 – 0.86; p<0.05) (supplementary table 3)

Discussion

Conceptualized nowadays as a continuum rather than a compartmentalised disease, (Dubois et al., 2016) the deterioration in function underlying dementia may begin years or decades before clinical onset.(Jack et al., 2010) To our knowledge, this is the first major population based longitudinal study with a nationally representative sample of men and women aged 50 years and older to examine whether internet use is associated with lower dementia risk. Only one published study has specifically investigated this association in a large longitudinal database, but this analysis was limited to men above 70 years.(Almeida et al., 2012)

We found the beneficial effect of internet use to be independent of age and SES. Although we cannot conclude that the association is causal from this observational study, there are several reasons why digital literacy may be protective. Internet use may reduce social isolation, increases social interactions, stimulates the learning of new things, increases the cognitive demand to master new skills using digital tools, and facilitates access to health and cultural information. Individuals who are internet users might have improved attention and psychomotor skills. Internet use might also enhance cognitive reserve by stimulation and also by reducing depressive symptoms.(Shapira, Barak, & Gal, 2007) For example, internet use might increase brain reserve or help employ more efficient cognitive networks to offset dementia(La Rue, 2010). Another

possible explanation for this association if that cognitively challenging activities may enhance neurotransmitters release in central nervous system and this might contribute to reduced cognitive decline.(Mather & Harley, 2016) There is also evidence that cognitive stimulating activities, such as use of internet, may increase the thickness of the fronto temporal association cortex. (G. H. Kim et al., 2015) It has been suggested that internet searching in middle-aged and older adults involves a greater extent of neural circuitry compared with reading text pages only and that the brain's responsiveness is altered in neural circuits related to decision making and complex reasoning. (Siddarth, D, & Bookheimer, 2009) Such mechanisms might support the higher cognitive reserve hypothesis as they might help delay the onset of overt cognitive impairment. (Stern, 2012)(Liberati, Raffone, & Olivetti Belardinelli, 2011)

In line with some earlier studies, known factors such as an increasing age and depressive symptoms were also linked to a higher dementia incidence. (Byers & Yaffe, 2011; Njegovan, Man-Son-Hing, Mitchell, & Molnar, 2001; Prince et al., 2015; Saczynski et al., 2010) The lack of a gender effect in this study is not unexpected, since the evidence is inconsistent, and may relate to sex differences in risky behaviours, such as smoking and sedentarism. Depressive symptoms were an independent risk factor associated with dementia, not a mediator. Brain alterations relevant to dementia, such as lower Brain-Derived Neurotrophic Factor (BDNF) levels, mitochondrial dysfunction, oxidative stress, inflammation and excitotoxicity may contribute to neuronal and glial cell death leading to decreased brain volume and cognitive dysfunction and increase dementia risk.(H. K. Kim, Nunes, Oliveira, Young, & Lafer, 2016) According to another longitudinal study internet use is associated with less depressive symptoms (Ford & Ford, 2009). Interestingly, the association between internet use and dementia was also independent of depression. According to Panza et al, depression may be the first step in a pathophysiological process leading up to mild cognitive impairment and dementia(Panza et al., 2010) On the other hand, depression treatment can be a modifiable factor decreasing dementia incidence.(Kessing, Forman, & Andersen, 2011; Lee, Lin, Sung, Liang, & Kao, 2016). In other studies, lower dementia risk was linked with higher education.(Le Carret et al., 2005; Prince et al., 2012) In our study, this effect was not observed in the final model. Internet use may be seen as a proxy for continuous educational attainment. Another interesting finding is that the protective effect of internet use may not depend on the "past" educational level but rather

on middle and late-life cognitive activity represented by digital literacy which is a recent phenomenon (about 20 years) for the age groups studied.(Wilson, Segawa, Boyle, & Bennett, 2012)

Some studies point out to the inequalities in socioeconomic internet use, called the digital divide, where older persons, female, low income and disadvantaged ethnic groups have lower access to internet. This was confirmed at the present study. In England, results from ELSA wave 6 shows that there is a strong age, gender and wealth gradient in internet usage. Nearly three-quarters of men (74%) and over six in ten of women (64%) report that they use the internet. However, usage of the internet declines with age, particularly for women. Among those aged 80 and above, 15% of the women report using the internet compared with 36% of the men. Just over half of men in the lowest wealth group report using the internet (52%), compared with almost nine-tenths of those in the highest wealth group (89%). These figures are 44% and 83%, respectively, for women(J Banks et al., 2014). It is legitimate to enquire whether internet use widens or reduces the socioeconomic inequalities already existing in society (Park, 2013). This is a key point for the present study, as we are dealing with older adults. It seems that this depends on the outcome. One investigation found a reduction in social inequalities in cognitive decline when digital literacy was included in the multivariable model, indicating that people of lower socioeconomic status who used internet had better cognitive performance than more affluent people who did not use the internet. (Xavier et al., 2014) This opens up an important possibility for dementia prevention, even among lower socioeconomic groups through potentially reducing inequalities in later life as a result of enhanced digital literacy (Xavier et al., 2013, 2014) It also strengthens the evidence for the 'use it or lose it' theory.(Tun & Lachman, 2010)

In line with our results, another study within the same population showed that internet use can also decrease the incidence of instrumental activities of daily living (IADL) impairment, which often coincides with cognitive decline, as it is part of the dementia process itself.(d'Orsi et al., 2014) The national representativeness of ELSA adds to the robustness of the results which indicate that internet use is an independent protective factor against dementia.

In our study the cumulative incidence estimated for those with 60 years or more was 8,18% in a 5-year follow-up on average, the incidence was estimated in 1,63% or 16,3 per 1000 persons/years, which is

congruent with the World Alzheimer Report 2015 for Western Europe of 17,3 per 1000 persons/years.(Prince et al., 2015) Our case definition using a combination of medical diagnosis and/or IQCODE >3,5 possibly helped to decrease the underdiagnosis gap that can reach 50% in primary care settings.(Connolly, Gaehl, Martin, Morris, & Purandare, 2011) The IQCODE sensitivity and specificity above 75% is considered reasonable and useful to rule out those without evidence of cognitive decline.(Harrison et al., 2015)

Among the limitations of this study is the absence of information on frequency and duration of internet use. Also, digital literacy may be understood as more than merely the use of internet. It certainly involves the knowledge of certain technical concepts more than the practice itself as well as the development of necessary skills (Sonck, N., Livingstone, S., Kuiper, E., and de Haan, 2011). Neither the knowledge acquired, nor the skills related to internet use, were assessed in the present study. Another potential limitation is that missing data on internet use were higher among dementia cases. We are probably also missing a number of cases who may have not been diagnosed with dementia. On the other hand, considering the sensitivity of our method, we can be reasonably confident about the individuals who were classified as having dementia. As strengths of this study we can mention the exclusion of individuals identified as having dementia (based on physician diagnosis and IQCODE score) in the first and second waves that created a necessary time interval to make sure that doubtful cases were correctly diagnosed/confirmed. It also created a temporal relationship between the predictor in 2002-03 and 2004-05 and the outcome (new cases incidence) investigated at the subsequent waves. The only other published study on this topic which we identified involved only men, had a comparatively older sample (aged over 70 years), a shorter follow-up, and had a less comprehensive set of covariates compared with this study.(Almeida et al., 2012)

The number of persons in the age groups with the highest rates of dementia is estimated to increase rapidly over the next few years, particularly in low and middle income countries (Brookmeyer et al., 2016) However, digital literacy is also increasing in society, which could be an important factor that could offset inequalities in dementia incidence related to lower education and lower SES.(Mayeda, Glymour, Quesenberry, & Whitmer, 2016)

In conclusion, countries where there are policy interventions to improve internet use in those over 50 years old or more may expect lower incidence rates for dementia over the coming years. Internet use is a modifiable factor and participation is already widening in most societies. It should be considered in health policies targeted at vulnerable populations. It also can be part of a complex multidomain intervention including personalised engagement in activities that maintain autonomy, independence and prevent dementia. Given the multiple challenges faced by ageing societies, digital inclusion may provide an important low cost strategy for maintaining cognitive health and preventing dementia.

References

Almeida, O. P., Yeap, B. B., Alfonso, H., Hankey, G. J., Flicker, L., & Norman, P. E. (2012). Older men who use computers have lower risk of dementia. *PloS One*, *7*(8), e44239. http://doi.org/10.1371/journal.pone.0044239

Banks, J., Nazroo, J., & Steptoe, A. (2014). *The dynamics of ageing: Evidence from the English Longitudinal Study of Ageing 2002-12 (Wave 6)*. (J. Banks, J. Nazroo, & A. Steptoe, Eds.) (1st ed.). London: Institute of Fiscal Studies. Retrieved from http://www.elsa-project.ac.uk/uploads/elsa/docs_w6/ELSA Wave 6 report.pdf

Bawden, D. (2008). Origins and Concepts of Digital Literacy. In C. Lankshear & M. Knobel (Eds.), *Digital literacies: Concepts, policies, and practices.* (2nd ed., pp. 17–32). New York: Peter lang Publishing inc.

Brookmeyer, R., Kawas, C. H., Abdallah, N., Paganini-Hill, A., Kim, R. C., & Corrada, M. M. (2016). Impact of interventions to reduce Alzheimer disease pathology on the prevalence of dementia in the oldest-old. *Alzheimer's & Dementia*. http://doi.org/10.1016/j.jalz.2016.01.004

Byers, A. L., & Yaffe, K. (2011). Depression and risk of developing dementia. *Nature Reviews. Neurology*, *7*(6), 323–31. http://doi.org/10.1038/nrneurol.2011.60

Connolly, A., Gaehl, E., Martin, H., Morris, J., & Purandare, N. (2011). Underdiagnosis of dementia in primary care: Variations in the observed prevalence and comparisons to the expected prevalence. *Aging & Mental Health*, *15*(8), 978–984. http://doi.org/10.1080/13607863.2011.596805

d'Orsi, E., Xavier, A. J., Steptoe, A., de Oliveira, C., Ramos, L. R., Orrell, M., … Marmot, M. G. (2014). Socioeconomic and Lifestyle Factors Related to Instrumental Activity of Daily Living Dynamics: Results from the English Longitudinal Study of Ageing. *Journal of the American Geriatrics Society*, *62*(9), 1630–1639. http://doi.org/10.1111/jgs.12990

Dubois, B., Hampel, H., Feldman, H. H., Scheltens, P., Aisen, P., Andrieu, S., … Jack, C. R. (2016). Preclinical Alzheimer's disease: Definition, natural history, and diagnostic criteria. *Alzheimer's & Dementia*, *12*(3), 292–323. http://doi.org/10.1016/j.jalz.2016.02.002

Ferri, C. P., Prince, M., Brayne, C., Brodaty, H., Fratiglioni, L., Ganguli, M., … Scazufca, M. (2005). Global prevalence of dementia: a Delphi consensus study. *Lancet*, *366*(9503), 2112–7. http://doi.org/10.1016/S0140-6736(05)67889-0

Ford, G., & Ford, S. (2009). Internet Use and Depression Among the Elderly. *Phoenix Center for Advanced Legal and Economic Public Policy*, *38*. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1494430

García-Casal, J. A., Loizeau, A., Csipke, E., Franco-Martín, M., Perea-Bartolomé, M. V., & Orrell, M.

(2016). Computer-based cognitive interventions for people living with dementia: a systematic literature review and meta-analysis. *Aging & Mental Health*, 1–14. http://doi.org/10.1080/13607863.2015.1132677

Harrison, J. K., Fearon, P., Noel-Storr, A. H., McShane, R., Stott, D. J., & Quinn, T. J. (2015). Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) for the diagnosis of dementia within a secondary care setting. In T. J. Quinn (Ed.), *Cochrane Database of Systematic Reviews*. Chichester, UK: John Wiley & Sons, Ltd. http://doi.org/10.1002/14651858.CD010772.pub2

Jack, C. R., Knopman, D. S., Jagust, W. J., Shaw, L. M., Aisen, P. S., Weiner, M. W., … Trojanowski, J. Q. (2010). Hypothetical model of dynamic biomarkers of the Alzheimer's pathological cascade. *The Lancet Neurology*, *9*(1), 119–128. http://doi.org/10.1016/S1474-4422(09)70299-6

Jorm, A. F. (1994). A short form of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): development and cross-validation. *Psychological Medicine*, *24*(1), 145–53. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8208879

Kessing, L. V., Forman, J. L., & Andersen, P. K. (2011). Do continued antidepressants protect against dementia in patients with severe depressive disorder? *International Clinical Psychopharmacology*, *26*(6), 316–322. http://doi.org/10.1097/YIC.0b013e32834ace0f

Kim, G. H., Jeon, S., Im, K., Kwon, H., Lee, B. H., Kim, G. Y., … Na, D. L. (2015). Structural brain changes after traditional and robot-assisted multi-domain cognitive training in community-dwelling healthy elderly. *PLoS ONE*, *10*(4), e0123251. http://doi.org/10.1371/journal.pone.0123251

Kim, H. K., Nunes, P. V., Oliveira, K. C., Young, L. T., & Lafer, B. (2016). Neuropathological relationship between major depression and dementia: A hypothetical model and review. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *67*, 51–57. http://doi.org/10.1016/j.pnpbp.2016.01.008

La Rue, A. (2010). Healthy brain aging: role of cognitive reserve, cognitive stimulation, and cognitive exercises. *Clinics in Geriatric Medicine*, *26*(1), 99–111. http://doi.org/10.1016/j.cger.2009.11.003

Le Carret, N., Auriacombe, S., Letenneur, L., Bergua, V., Dartigues, J.-F., & Fabrigoule, C. (2005). Influence of education on the pattern of cognitive deterioration in AD patients: the cognitive reserve hypothesis. *Brain and Cognition*, *57*(2), 120–6. http://doi.org/10.1016/j.bandc.2004.08.031

Lee, C. W.-S., Lin, C.-L., Sung, F.-C., Liang, J.-A., & Kao, C.-H. (2016). Antidepressant Treatment and Risk of Dementia. *The Journal of Clinical Psychiatry*, 117–122. http://doi.org/10.4088/JCP.14m09580

Liberati, G., Raffone, A., & Olivetti Belardinelli, M. (2011). Cognitive reserve and its implications for rehabilitation and Alzheimer's disease. *Cognitive Processing*. http://doi.org/10.1007/s10339-011-0410-3

Llewellyn, D. J., Lang, I. A., Langa, K. M., & Huppert, F. A. (2008). Cognitive function and psychological well-being: findings from a population-based cohort. *Age and Ageing*, *37*(6), 685–689. http://doi.org/10.1093/ageing/afn194

Mangialasche, F., Kivipelto, M., Solomon, A., & Fratiglioni, L. (2012a). Dementia prevention: current epidemiological evidence and future perspective. *Alzheimer's Research & Therapy*, *4*(1), 6. http://doi.org/10.1186/alzrt104

Mangialasche, F., Kivipelto, M., Solomon, A., & Fratiglioni, L. (2012b). Dementia prevention: current epidemiological evidence and future perspective. *Alzheimer's Research & Therapy*, *4*(1), 6. http://doi.org/10.1186/alzrt104

Marques, L. P., Schneider, I. J. C., & D'Orsi, E. (2016). Quality of life and its association with work, the Internet, participation in groups and physical activity among the elderly from the EpiFloripa survey, Florianópolis, Santa Catarina State, Brazil. *Cadernos de Saude Publica*, *32*(12), e00143615. http://doi.org/10.1590/0102-311X00143615

Mather, M., & Harley, C. W. (2016). The Locus Coeruleus: Essential for Maintaining Cognitive Function and the Aging Brain. *Trends in Cognitive Sciences*, *20*(3), 214–226. http://doi.org/10.1016/j.tics.2016.01.001

Matthews, F. E., Stephan, B. C. M., Robinson, L., Jagger, C., Barnes, L. E., Arthur, A., … Cognitive Function and Ageing Studies (CFAS) Collaboration. (2016). A two decade dementia incidence comparison from the Cognitive Function and Ageing Studies I and II. *Nature Communications*, *7*, 11398. http://doi.org/10.1038/ncomms11398

Mayeda, E. R., Glymour, M. M., Quesenberry, C. P., & Whitmer, R. A. (2016). Inequalities in dementia incidence between six racial and ethnic groups over 14 years. *Alzheimer's & Dementia*. http://doi.org/10.1016/j.jalz.2015.12.007

Ngandu, T., Lehtisalo, J., Solomon, A., Levälahti, E., Ahtiluoto, S., Antikainen, R., … Jula, A. (2015). A 2 year multidomain intervention of diet , exercise , cognitive training , and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. *Lancet*, *6736*(15), 1–9. http://doi.org/10.1016/S0140-6736(15)60461-5

Njegovan, V., Man-Son-Hing, M., Mitchell, S. L., & Molnar, F. J. (2001). The Hierarchy of Functional Loss Associated With Cognitive Decline in Older Persons. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *56*(10), M638–M643. http://doi.org/10.1093/gerona/56.10.M638

Norton, S., Matthews, F. E., Barnes, D. E., Yaffe, K., & Brayne, C. (2014). Potential for primary prevention of Alzheimer's disease: an analysis of population-based data. *The Lancet Neurology*, *13*(8), 788–794. http://doi.org/10.1016/S1474-4422(14)70136-X

Office Of National Statistics. Internet Access Quarterly Update 2011 Q4. (2011).

Office Of National Statistics. Internet Access Quaterly Update 2015 Q1. (2015).

Panza, F., Frisardi, V., Capurso, C., D'Introno, A., Colacicco, A. M., Imbimbo, B. P., … Solfrizzi, V. (2010). Late-life depression, mild cognitive impairment, and dementia: possible continuum? *The American Journal of Geriatric Psychiatry : Official Journal of the American Association for Geriatric Psychiatry*, *18*(2), 98–116. http://doi.org/10.1097/JGP.0b013e3181b0fa13

Park, Y. J. (2013). Offline Status, Online Status: Reproduction of Social Categories in Personal Information Skill and Knowledge. *Social Science Computer Review*, *31*(6), 680–702. http://doi.org/10.1177/0894439313485202

Prince, M., Acosta, D., Ferri, C. P., Guerra, M., Huang, Y., Llibre Rodriguez, J. J., … Liu, Z. (2012). Dementia incidence and mortality in middle-income countries, and associations with indicators of cognitive reserve: a 10/66 Dementia Research Group population-based cohort study. *Lancet*, *380*(9836), 50–8. http://doi.org/10.1016/S0140-6736(12)60399-7

Prince, M., Wimo, A., M, G., GC, A., YT, W., & M, P. (2015). *World Alzheimer Report 2015 The Global Impact of Dementia An analysis of prevalence, incidence, cost and trends*. *Alzheimer's Disease International*. London.

Ritchie, K., Carriere, I., Ritchie, C. W., Berr, C., Artero, S., & Ancelin, M.-L. (2010). Designing prevention programmes to reduce incidence of dementia: prospective cohort study of modifiable risk factors. *Bmj*, *341*(aug05 2), c3885–c3885. http://doi.org/10.1136/bmj.c3885

Saczynski, J. S., Beiser, A., Seshadri, S., Auerbach, S., Wolf, P., & Au, R. (2010). Depressive symptoms and risk of dementia. *Neurology*, *75*(1), 35. Retrieved from http://www.neurology.org/content/75/1/35.short

Satizabal, C. L., Beiser, A. S., Chouraki, V., Chêne, G., Dufouil, C., & Seshadri, S. (2016). Incidence of Dementia over Three Decades in the Framingham Heart Study. *New England Journal of Medicine*, *374*(6), 523–532. http://doi.org/10.1056/NEJMoa1504327

Shapira, N., Barak, a, & Gal, I. (2007). Promoting older adults' well-being through Internet training and use. *Aging & Mental Health*, *11*(5), 477–84. http://doi.org/10.1080/13607860601086546

Siddarth, P., D, & Bookheimer, S. Y. (2009). Your Brain on Google : Patterns of Cerebral Activation during Internet Searching. *American Journal Geriatric Psychiatry*, (February), 116–126.

Sonck, N., Livingstone, S., Kuiper, E., and de Haan, J. (2011). *Digital literacy and safety skills*. London. Retrieved from http://eprints.lse.ac.uk/33733

Steffick D. (2000). *Documentation of affective functioning measures in the Health and Retirement Study (HRS/AHEAD Documentation Report No. DR-005)*. Ann Arbor.

Steptoe, A., Breeze, E., Banks, J., & Nazroo, J. (2013). Cohort profile: The English Longitudinal Study of Ageing. *International Journal of Epidemiology*, *42*(6), 1640–1648. http://doi.org/10.1093/ije/dys168

Stern, Y. (2012). Cognitive reserve in ageing and Alzheimer's disease. *Lancet Neurology*, *11*(11), 1006–12. http://doi.org/10.1016/S1474-4422(12)70191-6

Tun, P. A., & Lachman, M. E. (2010). The association between computer use and cognition across adulthood: use it so you won't lose it? *Psychology and Aging*, *25*(3), 560–8. http://doi.org/10.1037/a0019543

Wilson, R. S., Segawa, E., Boyle, P. a, & Bennett, D. a. (2012). Influence of late-life cognitive activity on cognitive health. *Neurology*. http://doi.org/10.1212/WNL.0b013e31824f8c03

Wu, Y.-T., Fratiglioni, L., Matthews, F. E., Lobo, A., Breteler, M. M. B., Skoog, I., & Brayne, C. (2016). Dementia in western Europe: epidemiological evidence and implications for policy making. *The Lancet Neurology*, *15*(1), 116–124. http://doi.org/10.1016/S1474-4422(15)00092-7

Xavier, A. J., D'Orsi, E., de Oliveira, C. M., Orrell, M., Demakakos, P., Biddulph, J. P., & Marmot, M. G. (2014). English Longitudinal Study of Aging: Can Internet/E-mail Use Reduce Cognitive Decline? *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *69*(9), 1117–1121. http://doi.org/10.1093/gerona/glu105

Xavier, A. J., D'Orsi, E., Wardle, J., Demakakos, P., Smith, S. G., & von Wagner, C. (2013). Internet use and cancer-preventive behaviors in older adults: findings from a longitudinal cohort study. *Cancer Epidemiology, Biomarkers & Prevention : A Publication of the American Association for Cancer Research, Cosponsored by the American Society of Preventive Oncology*, *22*(11), 2066–74. http://doi.org/10.1158/1055-9965.EPI-13-0542

Table 1 Baseline characteristics of participants at 2002-03 and cumulative incidence of dementia (%) from 2006-07 to 2012-13 estimated by Kaplan-Meier failure function from 2006-07 to 2012-13, English Longitudinal Study on Ageing, England

		Total (n = 8,238)	%	Cumulative incidence of dementia (n = 301) %	95% CI
Sex	Men	3,713	45.07	4.49	3.77-5.36
	Women	4,525	54,93	5.42	4.70-6.25
Age:	50-59 years old	3,155	38,30	0.72	0.45-1.14
	60-69 years old	2,578	31,29	3.14	2.45-4.04
	70-79 years old	1,823	22.13	11.13	9.43-13.12
	≥80 years old	682	8.28	29.06	24.03-34.87
Marital status:					
	Married	5,590	67.86	4.16	3.59-4.82
	Not married	2,648	32.14	6.95	5.87-8.23
Education:					
	No qualification	3,198	38.82	8.09	6.98-9.36
	Intermediate	4,040	49.04	3.63	3.03-4.36
	Degree	1,000	12.14	2.44	1.58-3.77
Wealth (quintile)					
	1st	1,374	16.68	9.66	7.83-11.88
	2nd	1,581	19.19	5.86	4.60-7.45
	3rd	1,683	20.43	4.68	3.62-6.04
	4th	1,768	21.46	3.99	3.07-5.19
	5th	1,832	22.24	2.92	2.17-3.92
Hypertension					
	No	5,127	62.24	3.88	3.31-4.55
	Yes	3,111	37.76	7.01	6.00-8.18
Diabetes					
	No	7,685	93.29	4.65	4.13-5.24
	Yes	553	6.71	10.74	7.89-14.55
Stroke					
	No	7,936	96.33	4.71	4.19-5.29
	Yes	302	3.67	14.95	10.42-21.19
Coronary heart disease					
	No	6,625	80.42	4.24	3.71-4.84
	Yes	1,613	19.58	8.67	7.10-10.57
Cancer					
	No	7,757	94.16	4.99	4.45-5.59
	Yes	481	5.84	5.49	3.47-8.62
Impaired mobility					
	No	3,613	59.55	2.59	2.06-3.26
	Yes	4,625	40.45	7.12	6.28-8.08
Cognition index		0.01μ	±0.62δ	-0.46	-0.53--0.38
Depressive symptoms	No	7,014	85.14	4.34	3.81-4.93
	Yes	1,224	14.86	9.29	7.48-11.50
Internet use					

No§	4,906	59.55	7.71	6.85-8.69
Yes§§	3,332	40.45	1.65	1.23-2.21

§§People that reported internet use at 2002-03 and/or 2004-05
§People that reported no internet use at 2002-03 nor 2004-05
₮Cumulative incidence of dementia estimated by Kaplan Meier failure function
☐ 95% CI (confidence interval)
μ mean
δ Standard Deviation

Table 2. Adjusted hazard ratios (HR) of dementia from 2006-07 to 2012-13 with 95% confidence intervals (95% CI) estimated through Cox regression models, by covariates at baseline and use of internet at 2002-03 and/or 2004-05, English Longitudinal Study on Ageing, England

		Model 1 HR	95% CI	Model 2 HR	95% CI	Model 3 HR	95% CI
Sex	Men	1.00		1.00		1.00	
	Women	0.98	0.77-1.25	0.98	0.77-1.26	0.99	0.77-1.28
Age	50-59 years old	1.00		1.00		1.0	
	60-69 years old	3.82	2.24-6.51**	3.65	2.14-6.22**	3.40	1.99-5.80**
	70-79 years old	12.39	7.47-20.53**	11.37	6.83-18.92**	9.38	5.61-15.68**
	≥80 years old	36.51	21.47-62.09**	32.67	19.08-55.93**	23.71	13.74-40.91**
Marital status							
	Not married	1.00		1.00		1.0	
	Married	0.73	0.56-0.95*	0.75	0.57-0.97*	0.76	0.58-1.00
Education							
	No qualification	1.00		1.00		1.0	
	Intermediate	0.84	0.65-1.07	0.83	0.65-1.07	0.96	0.74-1.23
	Degree	0.91	0.55-1.50	0.90	0.54-1.49	1.16	0.70-1.93
Wealth (quintile)							
	1st	1.00		1.00		1.00	
	2nd	0.71	0.51-1.00**	0.71	0.51-1.00	0.73	0.52-1.02
	3rd	0.60	0.42-0.85**	0.61	0.43-0.86**	0.67	0.47-0.95*
	4th	0.61	0.42-0.87**	0.63	0.44-0.92*	0.74	0.51-1.07
	5th	0.47	0.31-0.71**	0.51	0.33-0.76**	0.63	0.42-0.95*
Internet use							
	No**	1.00			1.00	1.0	
	Yes*	0.52	0.36-0.73**	0.52	0.37-0.73**	0.60	0.42-0.85*
Hypertension							
	No			1.00		1.0	
	Yes			1.15	0.91-1.46	1.13	0.89-1.42
Diabetes							
	No			1.00		1.0	
	Yes			1.46	1.03-2.07*	1.34	0.94-1.90
Stroke							
	No			1.00		1.0	
	Yes			1.43	0.95-2.16	1.23	0.21-1.86
Coronary heart disease							
	No			1.00		1.0	
	Yes			1.13	0.87-1.46	1.05	0.81-1.36
Cancer							
	No			1.00		1.0	
	Yes			0.98	0.60-1.58	0.98	0.60-1.58
Impaired mobility							
	No					1.0	
	Yes					1.24	0.93-1.65
Cognition index						0.44	0.36-0.53**
Depressive symptoms	No					1.0	
	Yes					1.55	1.17-2.04**

HR: hazard ratios
95% CI (confidence interval)
* $P < 0.05$ **p<0.001

Supplementary Table 1 – Sensitivity analysis

Adjusted hazard ratios (HR) of dementia from 2008-09 to 2012-13 with 95% confidence intervals (95% CI) estimated through Cox regression models, by covariates at baseline and use of internet at 2002-03 and/or 2004-05, English Longitudinal Study on Ageing, England

		HR adjust	95% CI	p
Sex	Men	1.00		
	Women	1.01	0.74-1.38	0.905
Age	50-59 years old	1.00		
	60-69 years old	3.60	1.87-6.90	<0.001
	70-79 years old	10.42	5.57-19.47	<0.001
	≥80 years old	26.00	13.31=50.77	<0.001
Marital status				
	Not married	1.00		
	Married	0.85	0.62-1.17	0.342
Education				
	No qualification	1.00		
	Intermediate	0.99	0.73-1.34	0.978
	Degree	1.37	0.76-2.46	0.290
Wealth (quintile)				
	1st	1.00		
	2nd	1.05	0.71-1.57	0.777
	3rd	0.84	0.55-1.29	0.449
	4th	0.76	0.47-1.23	0.277
	5th	0.65	0.38-1.09	0.108
Hypertension				
	No	1.00		
	Yes	1.15	0.86-1.52	0.329
Diabetes				
	No	1.00		
	Yes	1.30	0.85-2.01	0.218
Stroke				
	No	1.00		
	Yes	1.21	0.72-2.03	0.454
Coronary heart disease				
	No	1.00		
	Yes	1.10	0.80-1.50	0.551
Cancer				
	No	1.00		
	Yes	0.75	0.39-1.42	0.383
Impaired mobility				
	No	1.00		
	Yes	1.17	0.83-1.64	0.363
Cognition index		0.44	0.35-0.56	<0.001
Depressive symptoms	No	1.00		
	Yes	1.49	1.06-2.09	0.021
Internet use				
	No	1.00		
	Yes	0.56	0.37-0.85	0.007

Supplementary Table 2 – Sensitivity analysis

Adjusted hazard ratios (HR) of dementia from 2004-05 to 2012-13 with 95% confidence intervals (95% CI) estimated through Cox regression models, by covariates at baseline and use of internet at any moment before the onset of dementia from 2002-03 to 2012-13, English Longitudinal Study on Ageing, England

		HR adjust	95% CI	p
Sex	Men	1.00		
	Women	0.89	0.71-1.12	0.340
Age	50-59 years old	1.00		
	60-69 years old	2.76	1.67-4.56	<0.001
	70-79 years old	7.61	4.71-12.30	<0.001
	≥80 years old	18.50	11.14-30.73	<0.001
Marital status				
	Not married	1.00		
	Married	0.78	0.61-0.99	0.044
Education				
	No qualification	1.00		
	Intermediate	1.08	0.85-1.37	0.490
	Degree	1.36	0.86-2.16	0.189
Wealth (quintile)				
	1st	1.00		
	2nd	0.84	0.62-1.14	0.277
	3rd	0.78	0.56-1.07	0.126
	4th	0.85	0.60-1.19	0.342
	5th	0.73	0.50-1.07	0.115
Hypertension				
	No	1.00		
	Yes	1.12	0.90-1.39	0.274
Diabetes				
	No	1.00		
	Yes	1.22	0.88-1.69	0.214
Stroke				
	No	1.00		
	Yes	1.17	0.80-1.70	0.401
Coronary heart disease				
	No	1.00		
	Yes	1.13	0.89-1.44	0.285
Cancer				
	No	1.00		
	Yes	0.99	0.64-1.52	0.966
Impaired mobility				
	No	1.00		
	Yes	1.07	0.82-1.38	0.600
Cognition index		0.39	0.33-0.47	<0.001
Depressive symptoms	No	1.00		
	Yes	1.56	1.21-2.01	0.001
Internet use				
	No	1.00		
	Yes	0.42	0.30-0.56	<0.001

Supplementary Table 3 – Sensitivity analysis

Crude and adjusted Incidence rate ratios (IRR) of dementia from 2004-05 to 2012-13 with 95% confidence intervals (95% CI) estimated through Generalized Estimating Equations, by covariates at baseline and use of internet from 2002-03 to 2010-11, English Longitudinal Study on Ageing, England

	Crude IRR (95% CI)	Adjusted IRR (95% CI)
Sex[1]	1.04 (0.83 – 1.30)	0.66 (0.49 – 0.90)*
Age: 52-59 years	1 [ref]	1 [ref]
60-69	2.77 (1.65 – 4.65)*	2.10 (1.11 – 3.94)*
70-79	11.30 (7.12 – 17.95)*	6.30 (3.50 – 11.35)*
≥80	26.49 (16.55 – 42.41)*	14.13 (7.60 – 26.25)*
Education: Degree	1 [ref]	1 [ref]
Intermediate	1.29 (0.82 – 2.02)	1.12 (0.73 – 1.72)
No qualification	2.81 (1.81 – 4.34)*	1.25 (0.81 – 1.92)
Wealth (quartile): 1st	1 [ref]	1 [ref]
2nd	0.74 (0.57 – 0.97)*	0.95 (0.64 – 1.41)
3rd	0.48 (0.36 – 0.64)*	0.99 (0.66 – 1.50)
4th	0.32 (0.23 – 0.44)*	0.99 (0.62 – 1.59)
Hypertension[2]	1.75 (1.40 – 2.17)*	1.15 (0.86 – 1.55)
Diabetes[2]	2.14 (1.55 – 2.96)*	1.54 (1.01 – 2.35)*
Stroke[2]	2.87 (1.95 – 4.23)*	0.93 (0.51 – 1.67)
Coronary heart disease[2]	2.00 (1.58 – 2.54)*	1.41 (1.03 – 1.92)*
Cancer[2]	1.18 (0.76 – 1.84)	1.17 (0.67 – 2.04)
Cognition (1st tertile)[4]	3.55 (2.99 – 4.20)*	2.9 (1.67 – 3.13)*
Marital status[3]	0.58 (0.46 – 0.72)*	1.52 (1.09 – 2.13)*
Internet use	0.27 (0.19 – 0.38)*	0.57 (0.37 – 0.86)*

[1] Male is the reference group
[2] No illness is the reference group
[3] Not Married is the reference group
[4] 2nd / 3rd tertile is the reference group
* $P < 0.05$