



Mini-mental state examination trajectories after age 50 by religious affiliation and practice in Ireland

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Abstract

Religious attendance is sometimes associated with better health outcomes, although the link between religion and cognitive ageing is inconclusive. We aimed to assess differences in cognitive performance trajectories by religious affiliation and religious attendance. We further sought to test possible mechanisms for an association. Data from the Irish Longitudinal Study on Ageing (TILDA), a nationally representative study of the over 50 s population in Ireland, was used. We identified latent class trajectories of Mini Mental State Examination (MMSE) performance over five waves using Latent Growth Class Analysis (LGCA) on data from 7325 individuals. Multinomial logistic regression was used to estimate the likelihood of membership to each trajectory class by religious affiliation or non-affiliation, and by religious attendance and importance. Finally, we tested possible behavioural, psychological and social mechanisms. LGCA identified three trajectory classes, a ‘high start’ class, a ‘medium start’ class and a ‘low start’ class. There were no differences in class membership by religious affiliation or non-affiliation. Women who attended religious services were less likely to be in the low declining MMSE class. This effect was mediated by depressive symptoms, social network and smoking. Women who said religion was very important were more likely to be in the medium performing class, and this was not mediated. The cognitive trajectories of the over 50 s in Ireland vary. Variation was not influenced by religious affiliation. Religious attendance and importance had mixed effects on women’s cognition trajectories.

Keywords Religion · Cognition · Longitudinal · Ireland

Background

Small changes to cognitive performance in later life are accepted as a normal part of ageing; however, more substantial changes in cognition can have a large impact on individuals’ abilities to live independently and maintain good quality of life. Religious participation has been suggested as a possible protective factor for various aspects health. The weight of the evidence suggests that religiosity (religious beliefs, behaviour and attitudes) is protective of health,

though results have been mixed, and differ by health domain and measure of religiosity (Koenig et al. 2012).

The link between religion and cognition has received less attention than the link between religion and other health domains. Previous work on religion and cognition has found that being religious is associated with higher dementia mortality (Park et al. 2005), higher risk of dementia (Beeri et al. 2008), and slightly higher cognitive decline when comparing the religious to the non-religious (Yeager et al. 2006), but lower in the highly religious compared to the less religious (Hill et al. 2006; Kaufman et al. 2007; Kraal et al. 2019; Reyes-Ortiz et al. 2008; Van Ness and Kasl 2003; Yeager et al. 2006). A recent review of the association between religiosity and cognitive function found that 82% of the seventeen studies reviewed reported positive associations. The review largely drew evidence from Christian samples, and therefore was not able to assess the implications of religiosity in other affiliations or the non-affiliated (Hosseini et al. 2017).

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Studies have also begun to explore the mechanisms behind the religion-cognition relationship. Both religiosity and cognition have been shown to be associated with depressive symptomatology; two recent studies using European samples have found associations between religiosity and lower depressive symptoms (Opsahl et al. 2019; Orr et al. 2019), and this is supported by the wider literature (Smith et al. 2003). Depression has often been discussed as a potentially modifiable risk factor for cognitive decline and dementia; however, it remains unclear whether depression is a risk factor or an early symptom of cognitive decline (Almeida et al. 2017; Baumgart et al. 2015; McDermott and Ebmeier 2009). Corsentino and colleagues found a three-way interaction between gender, age and depressive symptoms in the effects of follow up cognitive function. They found that women, but not men, with high depressive symptoms and low religious attendance had worse cognitive scores (Corsentino et al. 2009). Similarly, Foong and colleagues found that intrinsic religiosity moderates the negative effect of depression on cognition (Foong et al. 2018). In a study of older Mexican-Americans, Reyes-Ortiz and colleagues found that, for participants with high depressive symptoms, high church attendance was associated with a slower decline in cognition (Reyes-Ortiz et al. 2008). However, none of these studies fully explained the association between cognitive health and religion.

Other mechanisms could be implicated in this association. The religion and health literature have often posited three main pathways through which religion can have a positive impact on health; firstly, religion is associated with better mental health and lower depression in most studies (as discussed above). Secondly, religion is also associated with social benefits, for example increased social participation and lower isolation and loneliness (Ellison and George 1994; Rote et al. 2012). Finally, religion is linked to certain health behaviours. Smoking, drinking and risk-taking are all lower in the religious, and also highly associated with health (Bartke and Schwarze 2008; Garrusi and Nakhae 2012; Homan and Boyatzis 2010; Hussain et al. 2019; Michalak et al. 2007). All three mechanisms outlined (mental health, social connectedness, health behaviours) also have demonstrated links to cognitive function (McDermott and Ebmeier 2009; Peters et al. 2008; Poey et al. 2017; Sabia et al. 2009). Further, these three domains are highly correlated.

A further complicating factor in the disentanglement of the religion-cognition relationship is cognition itself. Normal age-related cognitive decline, and the form it takes, are complex and may include a number of pathways (Deary et al. 2009). The majority of older adults only experience mild cognitive decline, which progresses slowly over time and has a minimal impact on their wellbeing. However, some older adults experience much faster onset of symptoms and decline. This has been shown to be in part related to

cognitive reserve and level of education (Deary et al. 2009). Little has been done to understand the probability of experiencing rapid cognitive decline by religious affiliation or involvement.

The current study takes advantage of a large dataset to analyse the cognitive trajectories of adults aged 50 and over. We then test the probability of experiencing rapid cognitive decline or maintaining cognition by religious affiliation, attendance, and importance. Finally, we test three main mechanisms for the association between religious involvement and cognitive trajectories, namely mental health (depressive symptoms), social connectedness (number of close family and friends), and health behaviours (smoking status).

Methods

Sample

This study uses data from 7325 adults aged 50 and over participating in The Irish Longitudinal Study on Ageing (TILDA). TILDA is a nationally representative, longitudinal study of the older population in Ireland. TILDA has collected data on the social, economic and health characteristics of 8174 participants aged 50 and over. TILDA participants were randomly sampled using a two-stage sampling design, which is described in detail elsewhere (Whelan and Savva 2013). The first wave of data collection was completed 2010, with new waves of data collection approximately every 2 years. Statistical methods used allowed all available data to be used. Participants with observations on the cognitive measure of interest (MMSE) at any wave were included. Participant numbers per wave were: Wave 1 = 5714; Wave 2 = 6732; Wave 3 = 5960; Wave 4 = 5326; Wave 5 = 4636. Participants with doctor diagnosed Parkinson's disease, Alzheimer's disease, dementia, organic brain syndrome or senility, or severe memory impairment at baseline were excluded from the current analyses ($n = 94$). We further excluded participants with missing data on the measures of interest (full details given in online Appendix A).

Measures

Cognitive measure: cognitive function is measured in TILDA using a battery of tests. The Mini Mental State Exam (MMSE) is a test of global cognition, used as a screening instrument to detect cognitive impairment (Folstein et al. 1975). In TILDA the MMSE was measured at Wave 1 by a research nurse during an in-centre or at-home health assessment, and at subsequent waves by a social interviewer during the at-home interview. The data collection method at Wave 1 resulted in a reduced sample size for this wave. However,

the analysis method allows for analysis of all available data; therefore this loss of data was somewhat ameliorated. The MMSE consists of a test which includes different tasks. On completion of the MMSE, participants are given a score from 0 to 30, with 0 representing no correct answers given, and 30 representing all correct answers given. The MMSE was collected at each wave of TILDA, enabling the analysis of data collected every 2 years over 8 years of follow-up.

Religious measures: all respondents were asked at Wave 1 about their religious affiliation, importance and practice. Religious affiliation was obtained through the question ‘What is your religion’? Responses included Catholic, Anglican/Church of Ireland/Episcopalian, Methodist, Presbyterian, Other Christian, Other religion, No religion. For the current analysis, we included all the religious in one group, and compared them to all those who reported to have no religion. Those with no religion were then routed past questions on religious practice and belief. Religious attendance was collected through the question ‘About how often do you go to religious services’? (Never/almost never; Once or twice a year; Every few months; Once or twice a month; Once a week; More than once a week). We recoded this item into a two-category item indicating the level of religious attendance, with those who attended at least once a month categorised as ‘high attenders’ and those who attended less frequently (including those who never attended, but not including the nonreligious) categorised as ‘low attenders’. Religious importance was captured with the question ‘How important would you say religion is in your life’? (Very important; Somewhat important; Not too important). Again, this measure was recoded into ‘high importance’ (very important) and ‘low importance’ (somewhat and not too important).

Mediator variables: we selected three putative mediator variables. These represent three separate, but interrelated mechanisms hypothesised to underlie the religion-health relationship. First, we test whether depressive symptoms, which have been shown to be a part of the religion and cognition relationship in the past, mediate the relationship. Depressive symptoms are measured using the CES-D measure (Radloff 1977). We test whether the size of the social network, measured in the number of close relatives and friends, has a mediating impact. Finally, we test a behavioural pathway, by including smoking status as a putative mediator. Smoking status was categorised as ‘never smoker’, ‘past smoker’ and ‘current smoker’. Smoking is the health behaviour most consistently associated with religiosity and was therefore chosen to test this mediation pathway. Other health behaviours are more complexly associated with religion (Koenig et al. 2012). All mediator variables were measured at baseline.

Covariates: control variables were selected on a theoretical basis. Included variables were age and age² (to account

for any possible nonlinear association between age and cognitive decline), as well as a number of socio-demographic (sex, education (none/primary; secondary or higher), marital status (married or cohabiting; never married; separated or divorced; widowed)) and health (doctor diagnosed stroke, high cholesterol, high blood pressure, diabetes; self-rated health (excellent, very good, good, fair, poor)) variables. Some covariates were not included due to statistical concerns. These include any substance abuse problem, which was not included due to small numbers reporting substance abuse problems ($n = 132$), and transient ischemic attack, again due to small numbers ($n = 177$).

Analysis strategy

Initial examination of the MMSE showed little change over time and high scores in the sample. We therefore conducted a Latent Class Growth Analysis (LCGA) to identify different latent trajectory classes among sub-groups of our sample. These LCGA models were fit using Mplus version 6.12 (Muthén and Muthén 2011). This approach allows for different groups of individual growth trajectories to vary around different means and results in separate growth models for each latent class. For this analysis, the variance and covariance estimates for growth factors within each class are set to zero, meaning that individual growth trajectories within each class are assumed to be homogeneous (Jung and Wickrama 2008). The following criteria were used to assess model fit: comparison of the Bayesian and adjusted Bayesian information criteria (BIC and aBIC; (Nylund et al. 2007); higher entropy and posterior class membership probabilities (Clark and Muthén 2009); statistically significant Lo-Mendell-Rubin likelihood ratio test, which compares the fit of the k -class model against the $k-1$ class model (Lo et al. 2001); the proportion of cases in each class exceeds at least 5% of the sample; and the emergence of distinctive and theoretically relevant classes (Ram and Grimm 2009).

Multinomial logistic regression was then used to test whether there were differences in the probability of being in each MMSE class in the religious compared to the non-religious. We then used multinomial logistic regression to examine the religious only and examined differences in probability of being in each MMSE class by level of religious service attendance. We obtained and presented relative risk ratios for model effects, and we plotted predicted probabilities using the margins and marginsplots commands. Finally, we use the khb command (available in Stata (Kohler and Karlson 2019)) which implements the decomposition of effects method developed by Karlson, Holm and Breen to test mediation effects for the three putative mediators. This method compares the estimated coefficients of two nested nonlinear probability models and decomposes the effect of a putative mediating variable on an outcome variable through

its relationship with the main variable of interest (Kohler et al. 2011). We used the disentangle command available in khb to retrieve individual mediation variable contributions to the total mediation effect.

Supplemental analysis

A first supplemental analysis sought to understand the practical implications of membership in MMSE trajectory classes by determining the percentage of participants who had a doctor diagnosis of dementia by the end of follow-up (Wave 5) in each MMSE trajectory class.

We also used an ordered categorical version of the attendance and importance variables in adjusted multinomial regression models for MMSE class to assess whether there were dose–response effects.

Results

Table 1 presents fit statistics for LGCA. These indices informed our selection of the three-class solution as moving from the three to four returned a non-significant result

Table 1 Growth mixture model fit indices

Number of classes	LMR-LRT	BIC	aBIC	Entropy	PMP
2 classes	7833.6***	103,809.1	103,764.6	0.74	0.92–0.94
3 classes	1427.7**	102,393.8	102,333.4	0.60	0.80–0.91
4 classes	1522.0	106,269.6	106,218.7	0.90	0.86–0.96

LMR–LRT=Lo–Mendell–Rubin likelihood ratio test; BIC Bayesian Information Criterion; aBIC=sample size adjusted BIC; PMP=range for the posterior membership probabilities

*** $p < 0.001$; ** $p < 0.05$

for the Lo–Mendell–Rubin likelihood ratio test and increased Bayesian and adjusted Bayesian information criteria (BIC and aBIC) coefficients.

Final LGCA results identified three latent classes for MMSE trajectories. MMSE trajectories over the first five waves of TILDA are illustrated in Fig. 1. The largest class represented over half of participants (53%) and was characterised by high baseline MMSE scores and a small increase in scores over time (High start class). The second class included a third of the sample (34%) and was characterised by slightly lower MMSE scores at baseline, and a slow decline over time (Mid start class). Finally, the smallest class included 13% of respondents and was characterised by low baseline scores, a small initial increase in scores, and a decline in scores after Wave 3. The characteristics of class members are presented in Table 2.

Multinomial logistic regression

We found no evidence of differences in probability of MMSE class membership by religious affiliation or non-affiliation, although women who were religious had a larger, nonsignificant, relative risk ratio (RRR) of being in the low start class than women who were nonreligious, relative to the high start class (Table 3).

After excluding the nonreligious, adjusted multinomial logistic regression results for the effect of the level of religious attendance showed that men with high and low attendance had equal probabilities of being in the mid start class ($RRR = 0.99$ 95% CI 0.83; 1.19) and the low start class ($RRR = 0.87$ 95% CI 0.65; 1.17) relative to the high start class (Online Fig. 2a). For women, high attendance was associated with a lower probability of being in the low start class ($RRR = 0.73$ 95% CI 0.56; 0.97). There was a nonsignificant indication that high attendance might be associated

Fig. 1

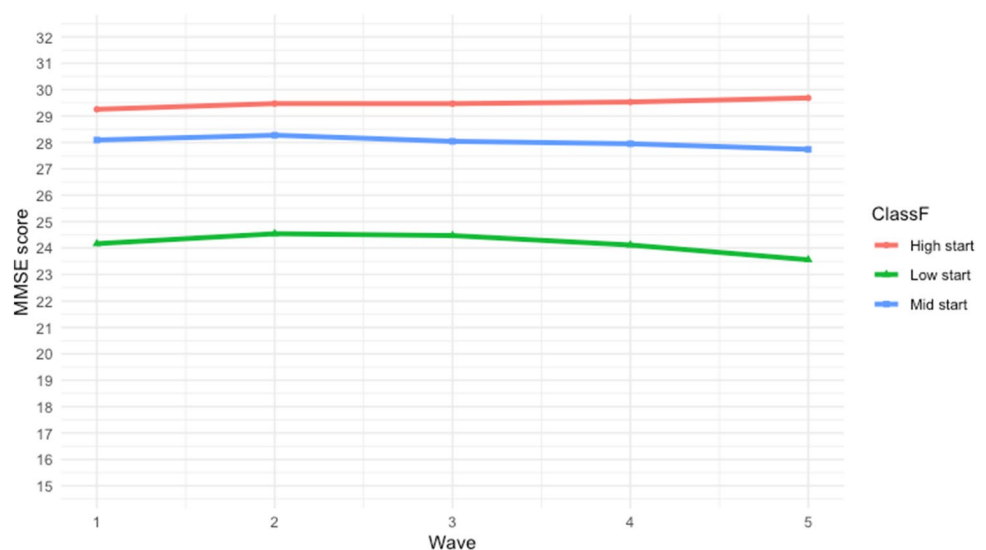


Table 2 Sample characteristics by MMSE latent class

Variable	Class 1 (High start) <i>n</i> = 3873	Class 2 (Mid start) <i>n</i> = 2517	Class 3 (Low start) <i>n</i> = 935
MMSE Wave 1	29.3 (0.9)	28.1 (1.4)	24.2 (3.3)
MMSE Wave 2	29.5 (0.8)	28.3 (1.4)	24.5 (3.4)
MMSE Wave 3	29.5 (0.8)	28.0 (1.4)	24.5 (3.2)
MMSE Wave 4	29.5 (0.7)	28.0 (1.5)	24.1 (3.6)
MMSE Wave 5	29.7 (0.5)	27.7 (1.3)	23.6 (3.7)
Age (baseline)	60.2 (7.8)	65.3 (9.3)	71.5 (10.3)
Religious (any affiliation)	93.3	95.9	98.0
Religious attendance* (%)			
High attender	67.1	73.2	72.8
Religious importance* (%)			
High importance	44.6	52.9	65.1
Sex (%)			
Women	57.8	49.5	51.9
Marital status (%)			
Married	76.1	68.6	51.1
Never married	7.9	9.9	14.1
Separated/Divorced	7.5	5.8	5.9
Widowed	8.5	15.7	28.9
Education (%)			
Primary/None	13.7	38.5	66.2
Secondary	43.6	42.3	26.4
Third level	42.7	19.2	7.4
Self-rated health (%)			
Excellent	20.0	14.0	7.2
Very good	33.0	25.9	23.0
Good	31.7	33.7	32.9
Fair	12.7	20.9	27.2
Poor	2.6	5.4	9.7
High blood pressure (%)	32.4	40.6	45.2
High cholesterol (%)	39.5	39.7	33.8
Stroke (%)	0.6	1.7	4.3
Diabetes (%)	5.5	9.0	12.0
Mediator variables			
CES-D (mean (SD))	5.2 (6.7)	5.9 (7.0)	7.7 (8.7)
Close relatives and friends (mean (SD))	10.9 (5.9)	11.3 (7.2)	10.1 (6.8)
Smoking status (%)			
Never	46.8	41.4	41.0
Past	37.5	39.6	36.6
Current	15.7	19.0	22.5

Due to the collection method for MMSE (see Methodology) MMSE scores have different sample sizes at each wave. *Percentages for religious attendance and religious importance do not account for nonreligious participants

with a higher probability of being in the mid start class relative to the high start class (RRR = 1.17 95% CI 0.98; 1.41) (Online Fig. 2b).

Table 3 Multinomial logistic regression for MMSE Class by religious versus nonreligious affiliation, relative risk ratios (*n* = 7325)

Class	Women (<i>n</i> = 3971)	Men (<i>n</i> = 3354)
Class 1: High start		
Class 2: Mid start		
Religious (vs. Nonreligious)	1.13 (0.75; 1.70)	1.26 (0.91; 1.74)
Class 3: Low start		
Religious (vs. Nonreligious)	2.88 (0.99; 8.35)	1.18 (0.65; 2.16)

Note: Models are adjusted for age, age², marital status, education, self-rated health, high blood pressure, high cholesterol, diabetes and stroke

Models showed that there were no differences by level of religious importance in men's probabilities of being in the mid start class (RRR = 0.91 95% CI 0.76; 1.08) or the low start class (RRR = 1.08 95% CI 0.83; 1.42), relative to the high start class (Online Fig. 3a). Women who had high religious importance were more likely to be in the mid start class relative to the high start class (RRR = 1.19 95% CI 1.01; 1.39). There were no significant differences in women's probabilities of being in the low start class relative to the high start class by religious importance (RRR = 1.26 95% CI 0.97; 1.62) (Online Fig. 3b).

Mediation models

Due to there being no observed effects for men, we tested mediation pathways for women only. Results for mediation effects models are given in Tables 4 and 5. The breakdown of the components of indirect effects, by mediating variable, is given in Online Appendix B, Tables B1 and B2. We present the results for mediation models by class outcomes.

Mid start class

The probability of being in the mid start class relative to the high start class was higher in those who attended religious services at least once a month, although this did not reach significance. This effect was not mediated by CES-D, number of relationships, or smoking status; however, the probability of high attenders being in the mid start class increased and became significant when CES-D, number of relationships and smoking status were added to the model. Examining the components of the difference showed that this confounding was fully explained by the inclusion into the model of current smoking status. Mediation models for religious importance showed that there was no mediation effect of CES-D, smoking or number of family and friends on the observed higher probability of being in the mid start

Table 4 Attendance and mediation effects, women ($n = 3819$)

Class	Total effect	p value	Direct effect	p value	Indirect effect	p value	% mediated
High start class (base outcome)	–		–		–		–
Mid start class	.16 (– .02; .35)	0.080	.21 (.02; .40)	0.027	– .05 (– .09; – .01)	0.016	–29.5
Low start class	– .30 (– .58; – .02)	0.038	– .18 (– .47; .11)	0.215	– .11 (– .18; – .05)	<0.001	38.7

Table 5 Importance and mediation effects, women ($n = 3819$)

Class	Total effect	p value	Direct effect	p value	Indirect effect	p value	% mediated
High start class (base outcome)	–		–		–		–
Mid start class	.17 (.01; .33)	0.035	.18 (.02; .34)	0.029	– .01 (– .02; .01)	0.398	–4.1
Low start class	.25 (– .01; .51)	0.060	.28 (.01; .54)	0.039	– .03 (– .06; .01)	0.136	–10.5

class relative to the high start class for those who were more highly religious.

Low start class

The probability of being in the low start class relative to the high start class was lower for high attender women. A mediation model showed that the effect of attendance was fully mediated by CES-D, count of close relatives and friends, and smoking status. These variables mediated 38.5% of the total effect. Examination of the components of difference showed that all three mediators contributed to the total mediation effect, with the most important contributions coming from CES-D and current smoking. No main or mediation effects were observed for level of religious importance.

Supplemental analysis

A total of 149 participants had received a dementia diagnosis by the end of follow-up (2% of the sample). The percentage of dementia diagnoses varied by MMSE trajectory class; 8% in the low start class developed dementia by Wave 5, compared to 2% in the mid start class and 1% in the high start class. The pattern was consistent in men and women (Online Appendix B).

We also tested the probabilities of membership to MMSE classes by including religious attendance and importance as ordered categorical variables (Online Appendix C). There were no significant effects for men, and no trends were observed. There were no significant effects or trends for women's probability of membership to the mid start class by attendance. However, we observed that women who attended once a week or more than once a week were significantly

less likely to be in the low start class than women who never or almost never attended services. We observed a trend in these results, with higher religious attendance being associated with lower probabilities of belonging to the low start class. Results for importance as an ordered categorical variable showed consistent results, with women who said that religion was somewhat important to them having a lower probability of being in the mid start class relative to the high start class.

Discussion

Our results show that in a nationally representative sample of the Irish population aged 50 and over, cognitive performance, as measured by the MMSE, was high and maintained high after eight years of follow-up for over half of respondents. However, over a third had medium high scores at baseline but experienced a slow decline over time, and over 10% had low scores at baseline and also experienced some decline. We found that there were no differences between the religiously affiliated and the non-affiliated in the probability of belonging to each of these classes. Women's probabilities of belonging to each class varied slightly by their level of religious attendance, with women with high religious attendance having a lower probability of being in the low start class. Counterintuitively, women with higher religious importance had a higher probability of being in the mid start class relative to the high start class. Importantly, both sets of effects were small.

We tested whether these effects for women were mediated by CES-D, the count of close relatives and friends or smoking status. We found that for high attendance women,

the lower probability of being in the low start class was fully mediated by these factors. This suggests that religious attendance is protective of cognitive function through multifactorial pathways. The strongest mediating factor was CES-D; the positive association between religious attendance and mental health in part explains the lower probability of lower cognitive scores. The second strongest mediating factor was current smoking. The lower likelihood of smoking in the high attenders lowered their probability of being in the low start class. Finally, the size of the social network had a small effect. Those with high religious attendance had larger social networks, and this was associated with lower probability of being in the low start class. Women with high religious service attendance also had a higher probability of being in the mid start class compared to those with low attendance; however, this did not reach significance. Mediation models showed that this effect was confounded by current smoking status, and once smoking was included in the models this effect became significant. The protective effect of lowered rates of smoking in women with high attendance therefore made this effect harder to observe. Mediation models showed no mediation effects for depressive symptoms, smoking or count of close relatives and friends for the relationship between religious importance and cognitive trajectory class.

There therefore appear to be 2 separate mechanisms underlying the relationship between religion and cognition for women. First, high religious attendance is associated with a number of areas of life which are in turn associated with better health. Older persons with better mental health, better health behaviours and larger social networks are less likely to have lower cognitive performance and cognitive decline (low start class). Conversely, we observed that those who considered religion to be more important had an increased probability of being in the mid start class instead of in the high start class. Considering religion to be important, while highly correlated with religious attendance, does not appear to be linked to these protective mechanisms. It is plausible that, as a measure of more private religious feeling, religious importance does not correlate with the same physical and psychological advantages as religious attendance.

There is a body of research which has found lower cognitive performance (Zuckerman et al. 2013, 2019), but not faster cognitive decline (Ritchie et al. 2014), among the religious. Among the posited explanations for these effects are higher non-conformity in the more intelligent, analytical as opposed to intuitive thinking style among the more intelligent, and a lower need for religion in the more intelligent (Zuckerman et al. 2013). Those with lower baseline cognitive abilities may be over-represented in the highly religious. We did not find definite evidence of poorer cognition among the religious; however, there were some indications that women who consider religion to be very important

may be at slightly higher risk of lower cognition. A slightly lower start point in cognitive scores associated with higher religiosity could help explain these discrepancies. The multidimensional disengagement theory of religion and health suggests that those suffering from poor health in later life disengage from formal religious practice, such as church attendance, while becoming more privately religious (Mindel and Vaughn. 1978; Levin et al. 2008). This confounds the relationship between religion and health. Religious attendance is more difficult to maintain in poor health, while religious importance may increase when faced with physical function declines as part of ageing. This could partly explain why we see poorer performance in religious women compared to nonreligious women, and why women who said that religion was more important to them were more likely to be in the mid start class relative to the high start class. Our results, though suggestive of this negative effect, were small and further were not significant for poorer performance in religious women. More needs to be done to clarify these relationships.

We only found effects for MMSE class membership in women. This has been the case in other studies (Corsentino et al. 2009). A study using TILDA data found that men's social network and depressive symptoms are equally, if not more, associated with their religious attendance as women's, suggesting these mediators are not behind the gender difference (Orr et al. 2019). The significant effects for women may be reflecting women's higher religious participation. When thinking of the protective effect seen against the probability of being in the low start class in particular, it is plausible women gain some form of cognitive reserve from religious participation (Corsentino et al. 2009; Scarmeas and Stern 2003). Women in Ireland in this age group are less likely to have participated in the labour market (Mosca and Wright 2018; Walsh 1993), and religion could be a mechanism for women to gain resources such as social networks, intellectual stimulation and access to opportunities, which men may in turn gain from their participation in the labour force. This does not explain why high importance women had poorer cognition compared to low importance women, however.

The detailed examination of other behavioural measures other than smoking was beyond the scope of this study. Smoking is the health behaviour most consistently associated with religiosity, with the religious being less likely to smoke in most religions and contexts (Garrusi and Nakhaee 2012; Koenig et al. 2012). In contrast, health behaviours such as diet, weight and physical activity have found both negative and positive associations (Ahrenfeldt et al. 2018; Cline and Ferraro 2006; Kim et al. 2003; Koenig et al. 2012). This area of research deserves further attention.

Our study has some limitations. Although the use of LGCA enables us to examine different cognition trajectories, the use of the MMSE measure has some

disadvantages. The MMSE was developed to detect cognitive impairment and is therefore not sensitive to minor cognitive changes in healthy populations. The MMSE is vulnerable to ceiling effects, and this has caused difficulty with its use to assess cognition in healthy populations (Pendlebury et al. 2010). However, our use of LGCA is able to somewhat address this by not relying on analysis of changes to an overall mean and grouping individuals by their baseline as well as trajectories over time. The current analyses are also limited by the fact that we only use one measure of global cognition; it is likely that observed results are more complex, and that the cognition-religiosity relationship may vary according to cognitive domain. However, use of other, more specific measures of cognitive function was beyond the scope of this study, and will be a useful contribution in the future. Another limitation is the possibility of bias in our sample. Although we were able to include a large proportion of the TILDA sample in our analysis, 9% were excluded due to missing data on the MMSE measure. These missing observations are largely due to the collection of the MMSE during the health assessment at Wave 1. Many older and frailer respondents did not complete the health assessment and therefore do not have MMSE data. This may bias our sample, as those who were healthier were more likely to be included. However, we were able to conduct sophisticated analyses using a wide range of control variables and data observed over time, which should help adjust for any bias introduced by missing data.

Conclusion

We find no differences in cognitive trajectories by religious affiliation per se for men or women. Once only those who were religious were considered, women with high attendance were slightly less likely to be in the low cognitive performance class, while women who considered religion very important were slightly more likely to be in the mid cognitive performance class. The effect of religious attendance was fully mediated by depressive symptoms, smoking and social network, suggesting that any protective effect of religious attendance can be explained by psychological, behavioural and social factors. These factors did not mediate the effect of religious importance. Results only showed small effects in women, and positive effects were fully explained by factors related to religious attendance. Further research into specific cognitive domains, as well as research into the mechanisms behind gender differences would be beneficial. Policies which enable those who are religious to maintain religious engagement may help protect both mental and cognitive health. Policies which seek to improve smoking

cessation, mental health and social engagement in secular as well as religious populations is likely to have positive impacts on cognitive health.

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Author contributions All authors contributed to the study conception and design. J.O. and M.W. conducted statistical analyses. J.O., M.W. and C.A.M. interpreted results. J.O. and C.A.M. drafted the manuscript. R.A.K. and M.W. reviewed the manuscript. R.A.K. designed the study and data collection phase. R.A.K. and C.A.M. supervised the project. C.A.M. revised the manuscript.

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Data availability A publicly available version of the TILDA dataset can be accessed on request via www.ucd.ie/issda/data/tilda/.

Code availability Not applicable.

Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare.

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