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Research Article

Associations of Religious Service Attendance With Cognitive Function in Midlife: Findings From The CARDIA Study

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Abstract

Objectives: Growing evidence suggests that religiosity is an important social determinant of health, including cognitive health. Yet most prior work focused on older adults or was conducted in racially and denominationally homogeneous regional samples. This study investigates the association of religious service attendance in midlife with cognitive function later in midlife.

Methods: Using data from the Coronary Artery Risk Development in Young Adults (CARDIA) study, a racially and geographically diverse prospective cohort study, we explored the association of religious service attendance in midlife with cognitive function 5 years later. Cognitive function was measured using four cognitive tests administered by CARDIA technicians. Multivariable linear regression was used for analyses. Primary analyses controlled for sociodemographics, physical health, depression, and prior religious involvement. Sensitivity analyses additionally controlled for baseline cognition and social support.

Results: Our study population included 2,716 participants (57.2% female, 44.9% Black, and mean age 50). In primary analyses, attending services more than weekly (compared to never) in midlife was associated with better global cognition (β = 0.14 standard deviations, 95% [confidence interval] CI = 0.02, 0.26) and verbal memory (β = 0.17 standard deviations, 95% CI = 0.04, 0.30), but not with processing speed (β = 0.04 standard deviations, 95% CI = −0.08, 0.16). A reverse association was observed with executive function (β = −0.16 standard deviations, 95% CI = −0.30, −0.02). Most findings persisted in analyses accounting for loss to follow-up via inverse probability weighting.

Discussion: Our findings suggest that frequent involvement in religious services at midlife is associated with better global cognition and verbal memory but worse executive function. There was no association with processing speed.

Keywords: Cognition, Religion, Social determinants

Religion is an integral part of many people's lives, with approximately 50% of the United States belonging to a church, mosque, or synagogue (Jones, 2021). Such widespread involvement elevates the importance of understanding how religion affects population health (Kawachi, 2020). Religiosity as a social determinant of health has

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previously been associated with many health outcomes and behaviors (Chen & VanderWeele, 2018; Feinstein et al., 2012; VanderWeele et al., 2017), including a reduction in all-cause and cardiovascular mortality, subclinical cardiovascular disease risk, and depression, all of which are major determinants of cognitive aging (Baumgart et al., 2015; Li, Okereke, et al., 2016; Li, Stampfer, et al., 2016; Pawlikowski et al., 2019).

While religion is a complex construct, the most widely studied measure has been the frequency of religious service attendance. A growing body of research has found associations between more frequent attendance and better cognition (Hosseini et al., 2016). This relationship has been shown to persist after accounting for other forms of social engagement, health behaviors, depressive symptoms, and baseline health and cognition (Corsentino et al., 2009; Kraal et al., 2019; Van Ness & Kasl, 2003; Yeager et al., 2006). The association has also been replicated in studies on cognitive trajectories showing slower rates of cognitive decline in adults who attended services at least monthly (Hill et al., 2006; Reyes-Ortiz et al., 2008). There is some additional evidence that newly initiating involvement in religious activity is associated with higher cognitive performance as well (Choi et al., 2016).

There are three main mechanisms through which religious involvement is hypothesized to benefit cognition: social engagement, psychological resources, and health behaviors (Hill, 2008; Idler, 2014; Kawachi, 2020). The first hypothesis posits that social engagement is necessary for healthy cognitive aging, and religious involvement is one form of social engagement, with unique elements including communal singing, prayer, text study, and socializing (Bassuk et al., 1999; Hill, 2008; Van Ness & Kasl, 2003). A second hypothesis is that connection with a religious community provides individuals with spiritual frameworks and positive psychological resources, such as a greater sense of meaning and optimism. This may reduce depression and anxiety and provide people with resources to cope with stress, which in turn can have beneficial affects on cognitive health (Achat et al., 2000; Hill, 2008; Zhang, 2010). A third hypothesis suggests religious involvement promotes healthy behaviors, including reduced smoking or alcohol consumption and greater physical activity, which have been shown to reduce cardiovascular risk factors that lead to increased risk of cognitive decline over the lifetime (Baumgart et al., 2015; Hill, 2008; Pawlikowski et al., 2019).

Despite the evidence to suggest a beneficial impact of religious service attendance on cognition, there are some gaps in the prior literature. First, while previous studies have focused on older adults, it is increasingly recognized that maintaining cognitive function is a lifelong process and that the effect of risk factors may begin earlier in life (Caunca et al., 2020; Grasset et al., 2019; Yaffe et al., 2014). Low midlife cognition has been associated with a greater likelihood of developing late-life mild cognitive impairment (MCI) and dementia, presenting opportunities for intervention if such individuals are identified earlier (Knopman et al., 2018). It is thus critical to examine whether religious service attendance may be protective for cognitive health in midlife before the onset of observable cognitive impairment. Focusing on younger adults also reduces the possibility of selection bias and reverse causation affecting the observed association (Hill, 2008). Second, the generalizability of prior work is limited; many studies have been conducted in primarily White, Christian samples that are not representative of the wider U.S. population. Religious involvement is known to vary widely by geographic region and religious denomination, and positive associations with cognition may not be present in all contexts (Hill, 2008; Hill et al., 2020; Ritchie et al., 2014). The impact of religion on health has also displayed differences by race and gender, underscoring the importance of studies that include racially and geographically diverse samples (Henderson et al., 2021). A final gap is that the vast majority of studies only assessed religion at one time point, making it difficult to understand the relationship of religious involvement over time with cognition. A recent cross-sectional study examined life-course church attendance, however, found protective associations only with some cognitive domains (Hill et al., 2020). Exploring multiple measures of religious attendance would allow for further understanding of the potential cognitive benefits of religious involvement over a wider span of the lifetime.

To address these gaps, in the present study, we investigate the longitudinal relationship between religious service attendance and cognitive function in a more racially and geographically diverse cohort of middle-aged adults going into older age from the Coronary Artery Risk Development in Young Adults (CARDIA) study. We hypothesize that more frequent service attendance in midlife will be associated with better cognitive function later in midlife, even after accounting for social support. A second aim investigates whether different patterns of religious service attendance from young to midadulthood ("changes in religious attendance") are associated with cognitive function in later midlife.

Method

Source Population

CARDIA is an ongoing prospective cohort study that aims to explore risk factors for coronary heart disease. The full study design has been described previously (Friedman et al., 1988). The study was initiated in 1985 and enrolled 5,115 individuals (51.6% Black and 48.4% White) between the ages of 18 and 30 years from four metropolitan areas: Birmingham, AL; Chicago, IL; Minneapolis, MN; and Oakland, CA. Study participants were balanced by sex (male and female), age, race (White and Black), and education at each enrollment site. Data were collected at the time

of study enrollment and at each of the follow-up examinations, which took place at years 2, 5, 7, 10, 15, 20, 25 (2010–2011), and 30 (2015–2016) postenrollment.

Exposure of Interest: Religious Service Attendance

Frequency of religious service attendance was collected in early adulthood (year 2, mean age 27, standard deviation [SD] = 3.5) and in midlife (year 25, mean age 50, *SD* = 3.6) using the question, "How often do you attend religious services at a church, synagogue, or house of worship." Informed by categories in previous literature, we categorized responses as more than once a week, 2–4 times a month (including those who went once a week), once a month or less, or never (reference category; Chen & VanderWeele, 2018; Feinstein et al., 2012; Henderson et al., 2021; Hill et al., 2006).

We additionally constructed a variable capturing patterns of religious service attendance between early adulthood and midlife ("change in religious attendance"). Individuals who moved more than one adjacent category (which we considered a meaningful change) were coded as attending "more" or "less," while individuals who did not move categories or moved only adjacent categories were coded as attending the same amount. Within the group attending the same amount, individuals were further separated into categories of "low" (infrequent attendance at both time points, reference category), "medium" (medium frequency of attendance at both time points), and "high" (frequent attendance at both time points).

Outcome of Interest: Cognitive Function in Midlife

Cognitive function was measured in 2010–2011 and in 2015–2016, at the 25-year and 30-year follow-up examinations through a battery of cognitive tests administered by trained CARDIA technicians. The digit symbol substitution test (DSST) is part of the Wechsler Adult Intelligence Scale and measures several components of processing speed, including working memory, executive function, and attention (Jaeger, 2018; Wechsler & Psychological Corporation, 1997). The interference score on the Stroop test measures attention and executive function by assessing the amount of processing needed to respond to one stimulus while suppressing another. The test score was comprised of the seconds to read color words printed in a different color plus the number of errors (Scarpina & Tagini, 2017; Stroop, 1992). Stroop scores were reverse-coded so that higher scores indicate better performance. The Rey Auditory Verbal Learning Test (RAVLT) long delay score measures verbal memory and the ability to memorize and recall words (Rosenberg et al., 1984). The Montreal Cognitive Assessment (MoCA) measures global cognition by including tests for short-term memory, visuospatial abilities, executive function, attention, concentration, working memory, language, and orientation to time and place (Nasreddine et al., 2005). The MoCA is a comprehensive test designed to discriminate between those with healthy cognition and those with MCI, while the DSST, Stroop, and RAVLT tests measure more specific cognitive domains and components. To facilitate comparison of estimates, each test score was *z*-scored based on the sample mean and standard deviation at the time of cognitive testing. Greater *z*-scores indicate better cognitive performance.

Covariates

Sociodemographic covariates included age, sex (male/female), race (Black/White), education (years completed), employment (working full-time, part-time, or in school/not working and not in school/missing), and marital status (married or partnered/single). Health behaviors and conditions included body mass index (BMI), smoking status (current/former or never), drinking status (yes/no), physical activity score (calculated based on duration and intensity, with higher scores indicating greater physical activity), depressive symptoms, and the number of self-reported health conditions. Depressive symptoms were measured by the Center for Epidemiological Studies—Depressive Scale 20-item version (range 0–60, Cronbach's α = 0.85–0.90), which asks participants how often in the previous week they have experienced symptoms including loneliness, poor sleep, or sadness (Radloff, 1977). Self-reported health conditions were measured by summing the number of conditions reported by participants (including hypertension, high cholesterol, heart problems, diabetes, kidney problems, thyroid problems, mental health problems, cancer, sickle cell, gallstones, liver problems, ulcers, and other). Social support was assessed at year 2 through four questions about the quality of personal relationships ("How often do you feel lonely?" "How often do you find yourself wishing someone would comfort you with a hug or some other physical affection?" "How often do you feel that other people really care for you?" and "How often do you wish you had more close friends?"), and at year 25 through three questions about the number and quality of relationships ("How many close friends do you have?" "How many relatives do you have that you feel close to?" and "How many of these close friends or close relatives do you have contact with at least once a month?"). The response options were five ordinal categories. The measurement of two distinct aspects of social support (emotional support vs. social network) is due to different data collection methods at years 2 and 25. We averaged response categories across all questions in a given year to calculate an average "social support" score (range 1–5; Cronbach's α = 0.76), with higher scores indicating higher levels of social support (either emotional support or size of support network depending on the year). Similar social support indexes have been used previously in studies of coronary heart disease and premature mortality

(Iribarren et al., 2005; Knox et al., 1998; Seeman & Syme, 1987). Most covariates were repeatedly assessed at all study visits, including years 2 and 25 of relevance to this study. Religious denomination was collected at study year 2, though not included as a covariate in analytic models as previous research indicates it is not associated with cognitive function and, therefore, not a potential confounder (Van Ness & Kasl, 2003; Yeager et al., 2006).

Statistical Analysis

We restricted our analytical sample (N = 2,716) to CARDIA participants who had data from at least one cognitive test at year 30 and information on religious service attendance at year 2 (young adulthood) and year 25 (midlife). In analyses of religious attendance in midlife with cognition 5 years later, we further restricted the sample to those with complete covariate data in year 25 (N ranging from 2,494 to 2,580). In analyses of change in religious attendance from young adulthood to midlife with cognition in midlife, we further restricted the sample to those with complete covariate data in year 2 (N ranging from 2,559 to 2,668). Different analytic sample sizes are due to differences in nonmissing cognitive information available for different cognitive tests (see Figure 1).

First, we summarized the baseline characteristics of our sample across categories of religious exposure at year 25, our primary exposure of interest. We used frequencies and proportions for categorical variables and means and standard deviations for normally distributed variables. Next, for the primary analyses of the associations between religious service attendance at midlife (year 25) and cognition 5 years later, three separate multivariable linear regression models were conducted. In line with previous research, we controlled for covariates that are often related to or theorized to affect both religious engagement and cognitive function (Hill et al., 2006; Reyes-Ortiz et al., 2008; Van Ness & Kasl, 2003). Model 1 adjusted for year 25 sociodemographic characteristics and study center. Model 2 additionally adjusted for year 25 health behaviors and conditions. In order to isolate the impact of religion in midlife, Model 3 adjusted for religious services in young adulthood (year 2) in addition to sociodemographic characteristics and health behaviors and conditions. Sensitivity analyses included a fourth model adjusting for all Model 3 variables as well as cognition at year 25 to reduce the possibility of reverse causation, and a fifth model adjusting for all Model 3 variables as well as a social network at year 25 to reduce confounding by existing social support. The MoCA was only administered at year 30, so for this test, we did not adjust for baseline cognition.

Analyses on the association between change in religious attendance from years 2 to 25 with cognition at year 30 were conducted in a similar manner but adjusting for year 2 covariates (baseline for this analysis). Model 1 adjusted for sociodemographic characteristics and study center, Model 2 adjusted additionally for health behaviors and conditions, and Model 3 additionally adjusted for emotional social support. We did not have a measure of depressive symptoms at year 2 so we did not adjust for this covariate in the change in religious attendance analyses. As a sensitivity analysis, we repeated the change in religious attendance analyses adjusting for year 25 covariates in Model 2, and including year 25 depressive symptoms.

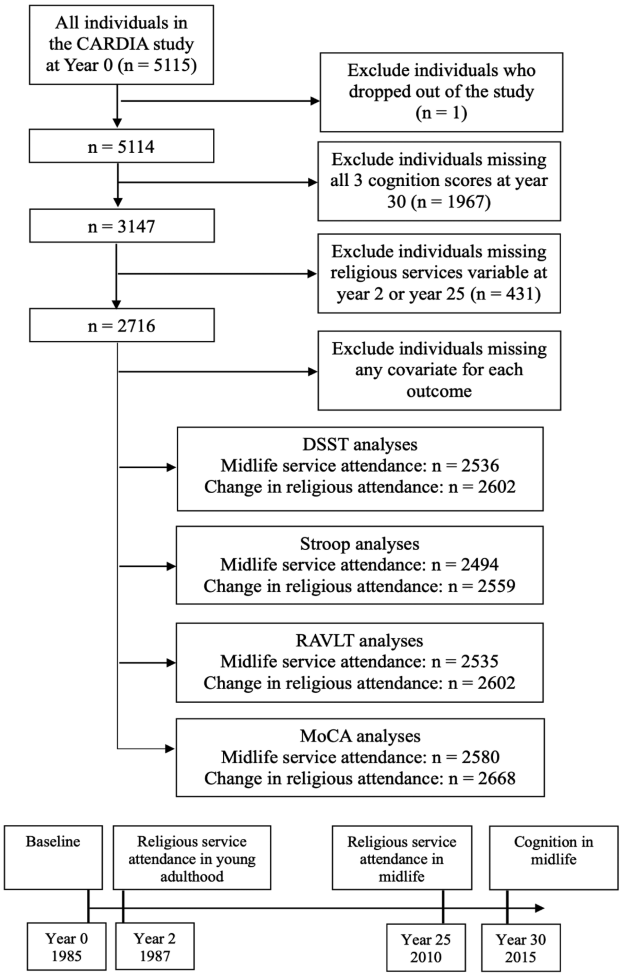

Figure 1. Study inclusion flow diagram. CARDIA = Coronary Artery Risk Development in Young Adults; DSST = digit symbol substitution test; RAVLT = Rey Auditory Verbal Learning Test; MoCA = Montreal Cognitive Assessment; Stroop = Stroop test.

Given the longitudinal nature of the study (ongoing for over 30 years), we accounted for loss to follow-up in our sample by calculating propensity scores for the probability of remaining in the study at year 30 as a function of study covariates at year 2. From these, we created stabilized inverse probability weights for remaining in the study, where the numerator was the marginal probability of remaining in the study (Seaman & White, 2016). As a sensitivity analysis, all models were repeated to account for the inverse probability censoring weights.

Results

Descriptive Analyses

Details of the sample selection are presented in Figure 1. Compared to the analytic samples, those who did not have

a complete outcome or exposure information were more likely to be male, Black, and younger. Those excluded from the analysis were also more likely at year 0 to be single, not working or not in school, a current smoker, and have less education (Supplementary Table 1). In the complete analytic sample at year 25, 57.2% of participants were female, and 55.1% were White. A majority of participants were working or in school and married or partnered, and the mean age was 50 years. Participant characteristics by religious service attendance at year 25 are displayed in Table 1, and characteristics by a change in religious attendance category are displayed in Supplementary Table 2. Those with a higher frequency of service attendance were more likely to be Black, female, less educated, and from Birmingham than those with a lower frequency of service attendance. They were also on average less physically active, had higher BMI, fewer depressive symptoms, more health conditions, larger social networks, and were less likely to be drinkers. The cohort was 28% Baptist, 25% other Protestant, 19% Catholic, 15% not religious, 3% Jewish, 9.5% other religion, and 0.5% were missing religious denomination. Approximately 75% of the sample reported attending religious services at year 25, with 9.9% attending more than once a week at year 2 and 14.7% attending more than once a week at year 25 (Figure 2). The majority (90.8%) of participants did not change more than one category of service attendance between years 2 and 25.

Religious Service Attendance in Midlife and Cognition

The association between religious service attendance and cognitive function varied depending on the cognitive

Table 1. Participant Sociodemographic and Health Characteristics Across Categories of Religious Service Attendance at Midlife (Year 25), *N* = 2,716, CARDIA Study

	Never	Once a month or less	2–4 times a month[a]	More than once a week
	(*N* = 690, 25.4%)	(*N* = 819, 30.2%)	(*N* = 807, 29.7%)	(*N* = 400, 14.7%)
Age, mean (*SD*)	50.3 (3.53)	50.3 (3.57)	50.0 (3.57)	50.0 (3.68)
Sex, female*	359 (52.0%)	422 (51.5%)	513 (63.6%)	260 (65.0%)
Race, Black*	166 (24.1%)	335 (40.9%)	411 (50.9%)	307 (76.8%)
Education, mean (*SD*)[b]*	15.5 (2.65)	15.2 (2.74)	15.3 (2.65)	14.6 (2.57)
Study center*				
Birmingham	57 (8.3%)	147 (17.9%)	262 (32.5%)	162 (40.5%)
Chicago	149 (21.6%)	211 (25.8%)	164 (20.3%)	89 (22.2%)
Minneapolis	209 (30.3%)	229 (28.0%)	196 (24.3%)	65 (16.2%)
Oakland	275 (39.9%)	232 (28.3%)	185 (22.9%)	84 (21.0%)
Marital status[b]				
Married/living with someone	428 (62.0%)	522 (63.7%)	512 (63.4%)	238 (59.5%)
Single	261 (37.8%)	289 (35.3%)	293 (36.3%)	159 (39.8%)
Employment[b]				
Working part- or full-time	571 (82.8%)	664 (81.1%)	643 (79.7%)	318 (79.5%)
Not working	119 (17.2%)	152 (18.6%)	164 (20.3%)	81 (20.2%)
Smoking status[b]				
Former/never	575 (83.3%)	667 (81.4%)	688 (85.3%)	350 (87.5%)
Current	107 (15.5%)	134 (16.4%)	111 (13.8%)	45 (11.2%)
Drinker status[b]*				
No	99 (14.3%)	120 (14.7%)	175 (21.7%)	182 (45.5%)
Yes	586 (84.9%)	692 (84.5%)	629 (77.9%)	217 (54.2%)
Physical activity score, mean (*SD*)[b]*	364 (269)	369 (290)	316 (263)	282 (271)
Depressive symptoms (CES-D scale), mean (*SD*)*	9.83 (7.87)	9.54 (7.59)	8.70 (7.58)	8.74 (7.17)
BMI, mean (*SD*)[b]*	28.8 (6.64)	29.2 (6.61)	30.6 (7.28)	32.6 (7.61)
Number of health conditions, mean (*SD*)*	2.12 (1.92)	2.06 (1.96)	2.24 (2.05)	2.46 (2.18)
Social network, mean (*SD*)[b]*	3.00 (0.827)	3.15 (0.815)	3.30 (0.874)	3.34 (0.891)

Notes: CARDIA = Coronary Artery Risk Development in Young Adults; *SD* = standard deviation; CES-D = Center for Epidemiological Studies—Depression scale; BMI = body mass index.

[a]This category includes individuals who reported attending 2–3 times a month and weekly.

[b]Missing observations (excluded from analytic sample): employment (*n* = 4), marital status (*n* = 14), education (*n* = 4), smoking status (*n* = 39), drinking status (*n* = 16), physical activity score (*n* = 13), BMI (*n* = 5), and social support (*n* = 4).

*$p < .05$ for differences across categories.

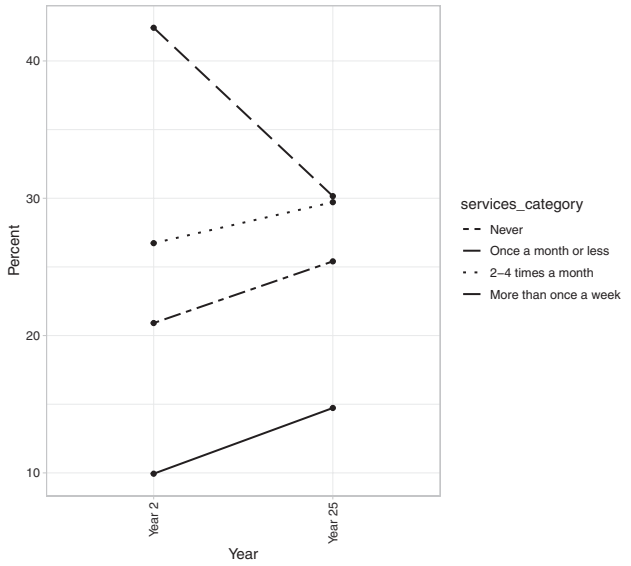

Figure 2. Change in religiosity: change in the proportion of individuals in each category of religious service attendance from year 2 to year 25 in the CARDIA study. CARDIA = Coronary Artery Risk Development in Young Adults.

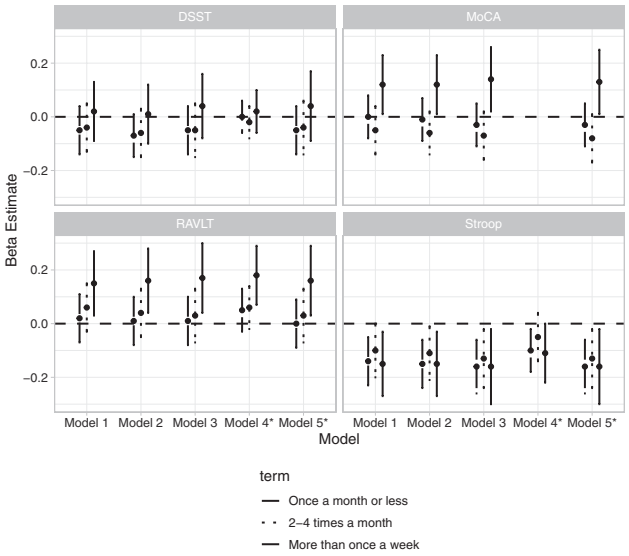

Figure 3. Multivariable association of religious service attendance at midlife (year 25) with cognitive function in midlife (year 30) in the CARDIA study. *Z*-standardized beta coefficients from linear regression models. Model 1 is adjusted for sociodemographic characteristics and study center at year 25. Model 2 is additionally adjusted for health conditions and behaviors at year 25. Model 3 is Model 2 additionally adjusted for religious services at year 2. Model 4 is Model 3 additionally adjusted for cognition at year 25. Model 5 is Model 3 additionally adjusted for social support at year 25. Reference group is "Never" attending. *Models 4 and 5 are sensitivity analyses. CARDIA = Coronary Artery Risk Development in Young Adults; DSST = digit symbol substitution test; RAVLT = Rey Auditory Verbal Learning Test; MoCA = Montreal Cognitive Assessment; Stroop = Stroop test.

domain (Figure 3, Supplementary Table 3 and Supplementary Table 6). In models adjusted for sociodemographic factors, health characteristics, and prior religious service attendance, compared to never attendees, those who attended religious services more than once a week performed better on the RAVLT (β = 0.17, 95% confidence interval [CI] = 0.04, 0.30) and MoCA (β = 0.14, 95% CI = 0.02, 0.26) but worse on the Stroop test (β = −0.16, 95% CI = −0.30, −0.02); for the Stroop test the negative associations were also seen in both lower categories of attendance (Model 3). Adjustments for sociodemographics alone (Model 1) or health conditions and sociodemographics alone (Model 2) were only marginally different from the estimates in the fully adjusted model, including prior religious services (Model 3). No associations were observed with DSST across all models.

Change in Religious Attendance and Cognition

There was no observed association between change in religious attendance and cognition for DSST or MoCA (Table 2). Individuals with high service attendance at both time points performed better on the RAVLT than those with low attendance at both time points (β = 0.10, 95% CI = 0.01, 0.19) accounting for sociodemographic and health characteristics. Individuals who attended less frequently over time had worse performance on the Stroop test compared to those with low attendance at both time points (β = −0.23, 95% CI = −0.43, −0.03) accounting for sociodemographic and health characteristics.

Sensitivity Analyses

For midlife religious service attendance analyses, additional adjustment for baseline (year 25) cognition did not meaningfully change the estimates for DSST and RAVLT (Figure 3, Model 4). However, estimates for Stroop scores were attenuated and no longer statistically significant in the two highest exposure categories. Adjustment for a social network at year 25 in addition to sociodemographic factors, health behaviors, and prior religious attendance did not meaningfully change any estimates (Figure 3, Model 5). For a change in religious attendance analyses, adjusting for emotional social support in addition to sociodemographic and health characteristics did not meaningfully change any estimates (Table 2). Additionally, when these analyses were repeated, adjusting for year 25 covariates, results remained overall the same, with the exception that those attending the same level (high frequency) no longer display significantly better RAVLT scores when adjusting for health behaviors, and those attending more frequently show significantly worse Stroop scores (Supplementary Table 5).

Religious service attendance analyses incorporating inverse probability weights (IPW) to account for loss to follow-up produced estimates that were essentially unchanged from those in primary analyses for the Stroop test and DSST (Supplementary Table 4). Estimates for RAVLT and MoCA coefficients were unchanged for models that included adjustment for prior religious service attendance, however, in models adjusting only for sociodemographic and health characteristics, estimates were attenuated slightly and no longer significant. For the change in religious attendance

Table 2. Association of Change in Religious Attendance From Early to Midlife (Years 2–25) With Cognitive Function in Midlife (Year 30) in the CARDIA Study

	Model 1	Model 2	Model 3
	β (95% CI)	β (95% CI)	β (95% CI)
DSST model coefficients			
Same level, low frequency	Ref	Ref	Ref
Less attendance	−0.02 (−0.20, 0.16)	−0.03 (−0.21, 0.15)	−0.03 (−0.21, 0.15)
More attendance	0.0 (−0.14, 0.14)	0.01 (−0.13, 0.15)	0.01 (−0.13, 0.15)
Same level, medium frequency	−0.04 (−0.13, 0.05)	−0.04 (−0.13, 0.05)	−0.04 (−0.13, 0.05)
Same level, high frequency	0.02 (−0.06, 0.10)	0.01 (−0.08, 0.10)	0.0 (−0.09, 0.09)
RAVLT model coefficients			
Same level, low frequency	Ref	Ref	Ref
Less attendance	−0.04 (−0.22, 0.14)	−0.04 (−0.22, 0.14)	−0.04 (−0.22, 0.14)
More attendance	0.01 (−0.13, 0.15)	0.01 (−0.13, 0.15)	0.01 (−0.13, 0.15)
Same level, medium frequency	0.01 (−0.08, 0.10)	0.02 (−0.07, 0.11)	0.02 (−0.07, 0.11)
Same level, high frequency	0.10* (0.01, 0.19)	0.10* (0.01, 0.19)	0.09* (0.0, 0.18)
Stroop model coefficients			
Same level, low frequency	Ref	Ref	Ref
Less attendance	−0.25* (−0.45, −0.05)	−0.23* (−0.43, −0.03)	−0.23* (−0.43, −0.03)
More attendance	−0.15 (−0.31, 0.01)	−0.15 (−0.31, 0.01)	−0.15 (−0.31, 0.01)
Same level, medium frequency	−0.08 (−0.18, 0.02)	−0.07 (−0.17, 0.03)	−0.08 (−0.18, 0.02)
Same level, high frequency	0.03 (−0.06, 0.12)	0.04 (−0.05, 0.13)	0.04 (−0.05, 0.13)
MoCA model coefficients			
Same level, low frequency	Ref	Ref	Ref
Less attendance	−0.10 (−0.27, 0.07)	−0.10 (−0.27, 0.07)	−0.10 (−0.27, 0.07)
More attendance	0.01 (−0.12, 0.14)	0.02 (−0.11, 0.15)	0.01 (−0.12, 0.14)
Same level, medium frequency	−0.04 (−0.13, 0.05)	−0.04 (−0.13, 0.05)	−0.04 (−0.13, 0.05)
Same level, high frequency	0.02 (−0.06, 0.10)	0.02 (−0.06, 0.10)	0.02 (−0.06, 0.10)

Notes: *Z*-standardized beta coefficients from linear regression models. Model 1 is adjusted for study center, employment status, marital status, age, sex, race, and years of education at year 2. Model 2 is additionally adjusted for BMI, smoking status, drinking status, physical activity score, and number of health conditions at year 2. Model 3 is Model 2 additionally adjusted for emotional social support at year 2. Reference group is attending "same level, low frequency." Results remained similar when we additionally accounted for IPW. CARDIA = Coronary Artery Risk Development in Young Adults; DSST = digit symbol substitution test; RAVLT = Rey Auditory Verbal Learning Test; MoCA = Montreal Cognitive Assessment; Stroop = Stroop test; CI = confidence interval; BMI = body mass index; IPW = inverse probability weights.
*$p < .05$; all p values are two-sided.

exposure, analyses incorporating IPW produced estimates that were essentially unchanged from those in primary analyses for the Stroop test, DSST, and MoCA (data not shown). RAVLT coefficients were similar, with the exception that attending services frequently at both time points was no longer significantly associated with better cognition.

Discussion

Our study found mixed results for the association between religious service attendance at midlife and cognition depending on the cognitive domain assessed. In alignment with our hypothesis that more frequent service attendance would be associated with better cognition, attending more than once per week was associated with better scores on the RAVLT long delay score (measuring verbal learning and short-term memory), and the MoCA (measuring global cognition) compared to those who never attended services. Both associations were evident even after accounting for social network and prior religious service attendance. Contrary to our hypothesis, we did not observe an association between service attendance in midlife and DSST (measuring working memory, executive function, and attention), and we found a negative association with Stroop scores (measuring attention and executive function). Regarding our secondary aim, we found no association between change in religious attendance and cognition as measured by the DSST or MoCA; those attending less over time had worse Stroop scores, and those attending frequently at both time points had better RAVLT scores. Overall these findings suggest that frequent religious involvement in midlife is associated with better global cognition, verbal learning, and short-term memory regardless of religious involvement in early adulthood or social network, however, these positive associations may not be present for all cognitive domains.

Our findings of positive associations between more than weekly service attendance and global cognition and verbal memory are consistent with previous literature (Chen & VanderWeele, 2018; Corsentino et al., 2009; Henderson et al., 2021; Hill et al., 2006; Hosseini et al.,

2019; Kraal et al., 2019; Reyes-Ortiz et al., 2008; Van Ness & Kasl, 2003; Yeager et al., 2006). While the specific tests used to assess cognition in prior studies have varied widely, the majority have measured global cognition, which is most similar to the MoCA in this study. Interestingly we did not see clear positive associations of less frequent categories of attendance with cognition, suggesting there may be a minimum level of involvement necessary for service attendance to impact cognition, or that there may be unique characteristics in those able to attend more than weekly. The persistence of the association after adjustment for social support is in alignment with several longitudinal studies as well (Corsentino et al., 2009; Kraal et al., 2019; Van Ness & Kasl, 2003; Yeager et al., 2006).

Our hypothesis that frequent service attendance would be associated with better cognition was not supported by our results for the DSST or Stroop tests. While this was unexpected, prior studies that assessed specific cognitive domains separately (rather than global cognition) have found either negative or no associations between service attendance and cognition (Hill et al., 2020; Ritchie et al., 2014). Conflicting results across cognitive tests in these studies and the current investigation suggest religious service attendance may affect cognitive domains differently, which is not captured in studies focusing only on global cognition. Indeed, Hill et al. examined multiple cognitive domains in their study and found positive associations with self-rated memory, negative associations with mental status and working memory, and no associations with overall cognitive function and episodic memory. Another study found group religious involvement to be more strongly positively associated with constructional ability than language and memory, supporting the theory that cognitive domains may be differentially affected by religious involvement (Jung et al., 2019). Referencing dual-process theory, Hill et al. hypothesize that rigid thought processes and ritualized lifestyles encouraged by many religions over a long period may encourage individuals to engage in automatic processing rather than analytical and reflective processing (Hill et al., 2020). This theory supports our finding that the Stroop scores were worse among frequent attenders, as that test measures the ability to inhibit habitual responses. Other cognitive functions, such as those related to memory or language abilities (which are captured by the MoCA and RAVLT tests), may be affected differently. Finally, some studies have shown that the DSST's sensitivity to age-related effects is due to motor speed rather than cognitive changes; as this cohort was fairly young this test may not be as sensitive to change (Jaeger, 2018). Future research assessing multiple cognitive domains may help characterize these distinctions, particularly in younger adults.

In our analyses of change in religious service attendance, we found those who attended less over time showed approximately 1/4 standard deviation worse Stroop scores, and those who had consistently frequent participation had higher RAVLT scores compared to those who attended consistently infrequently. While the RAVLT results are in line with a study of Korean adults that found that those with consistent participation in religious activity and those who newly participated had higher cognitive performance, we generally did not see associations with other cognitive outcomes, which is in contrast to this prior work (Choi et al., 2016). The largely null results in our study may be because most participants (approximately 90%) did not show a substantial change in their religious service attendance between the two time points. While few studies have examined religious change across the lifetime, stable participation during adulthood is not unexpected, supporting the generalizability of our results (Hayward & Krause, 2013). Lastly, while our study was fortunate to have two time points, we did not have measures of service attendance between years 2 and 25, limiting our ability to capture if someone changed patterns of attendance between those years. However, our null findings are supported by a recent study that found life-course religious attendance was not associated with overall cognitive function or episodic memory (Hill et al., 2020). As with other social determinants of health, it will be beneficial for future work to leverage studies that consistently measure aspects of religiosity over time to more fully categorize religious service attendance over the lifetime.

While this study assessed cognition in a fairly young cohort, the implications of these findings are important given that worse cognition in midlife is associated with progression to MCI and dementia later in life (Knopman et al., 2018). Identifying predictors of cognitive function earlier in time can support interventions before the accumulation of damage. In this sample, we find that those attending services more than weekly had up to approximately 1/4 standard deviation higher MoCA scores than those who never attended services (95% CI = 0.02, 0.26). This equates to 0.99 points on the unadjusted MoCA scale, which is roughly equivalent to the difference in cognitive function of 10 years of age found both in the current study and in a recent representative study of older U.S. adults (Dale et al., 2018). We find similar estimates with RAVLT, a test that captures verbal memory. The MoCA has shown high sensitivity to distinguish MCI from healthy aging, and both MoCA and RAVLT are important cognitive indicators. (Nasreddine et al., 2005). We also note that we did not find associations with the DSST, and we found opposite associations with the Stroop test; these results suggest differential associations of our predictor of interest with general cognition (MoCA) and verbal memory (RAVLT) and warrant more investigations of these relationships and their clinical impact.

This study had several strengths, including a sample with a more even balance of Black and White participants, a diverse range of religious beliefs, a wider geographic area in the United States, and multiple measures of cognition. This provides support for the association of religious service attendance and cognition in groups

beyond White Christians and Hispanic Americans. The present study's demographic characteristics are comparable to those in nationally representative studies examining the research question of religiosity and cognition (with the exception of a larger proportion of Black study participants in the current study). As such, these results can provide insight into the association of religious service attendance and cognition in the United States. Additionally, this study shows a temporal relationship between service attendance and cognition, providing a strong argument for causation. By investigating this relationship earlier in life, the potential for selection bias and reverse causation to impact the estimates is lessened. We further adjust for baseline cognition, social support, and prior religious involvement, reducing the possibility of confounding by existing social support or reverse causation, and highlighting the impact of religion in midlife on cognition, above and beyond religiosity earlier in life. We also adjusted for health behaviors at baseline, further reducing the possibility that people with healthier behaviors that become more involved religiously are driving the positive association (Hill, 2008). Our use of measures of religious service attendance at two time points is an additional strength, as this has rarely been examined in prior literature.

Our study also has some limitations. Religion is a complex construct; however, we only assessed attendance at religious services (Koenig et al., 2015). It is possible that people may be involved in the religion in ways other than communal praying, for example, through holiday celebrations, text study, or personal belief. In the current study, we were unable to capture how other forms of participation may affect cognition. Additionally, although we looked at two time points of service attendance (years 2 and 25), it is possible that attendance patterns could change substantially across those years. A further limitation is the amount of missing data from loss to follow-up across the 30 years of the study, leading to a biased analytic sample that had a higher proportion of individuals who were female, White, married, working, nonsmokers, older, and more educated than those who were not included in the analysis due to missing outcomes. Yet, loss to follow-up was fairly evenly distributed across categories of religious service attendance, and results incorporating inverse probability weighting to account for loss to follow-up did not differ substantially from the main analysis. Another limitation is inconsistencies in data collection methods over time that resulted in differences in the operationalization of social support between years 2 and 25, and an inability to adjust for anxiety. Relatedly, due to the wide variety of cognitive tests used in prior literature, we were not always able to make direct comparisons between our results and those of previous studies. Finally, as this is an observational study, unmeasured confounding may have affected the results despite our adjustment for many observed confounders.

We also did not examine associations among groups that may be differentially affected by religious involvement. For example, individuals with identities that are not supported by certain religious traditions may find involvement leads to anxiety, depression, or guilt, and subsequently worse (cognitive) health (Hill, 2008; Li, Stampfer, et al., 2016). Alternatively, certain groups may benefit more substantially from religious involvement as has been suggested in prior studies among individuals with depressive symptoms and Black women (Corsentino et al., 2009; Henderson et al., 2021; Kraal et al., 2019; Levin et al., 2005; Reyes-Ortiz et al., 2008). Future research should focus on exploring which groups might benefit most from religious involvement, better characterizing what aspects of religious service attendance (e.g., communal, personal, and intellectual) are important for cognition, and identifying mediators of this relationship.

In conclusion, this longitudinal study provides evidence for a mostly positive association of more than weekly religious service attendance during midlife with cognitive health in a cohort of middle-aged adults. This relationship was found in a racially diverse sample of U.S. adults from multiple geographic regions and religions, which builds on prior work and provides greater generalizability of these results. However, as others have noted, research supporting a positive association between religion and health should not be taken as an endorsement of religion as a "treatment" without further examining the nuances of how religion interacts with different identities (Kawachi, 2020). Instead, research such as this provides support for incorporating discussions around religion into care for individuals who already hold such beliefs as a way to enhance people's existing supports and encourage culturally relevant interventions. It may also help in identifying beneficial aspects of other communal activities. Finally, this research suggests the possible benefits of collaboration between religious organizations and public health initiatives to strengthen healthy cognitive aging.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.Funding

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Conflict of Interest

None declared.

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Author Contributions

I. S. Nelson and A. Z. A. Hazzouri designed and conceptualized the study with support from K. Yaffe. I. S. Nelson analyzed and interpreted the data and drafted the manuscript. K. Kezios and A. Z. A. Hazzouri contributed to data interpretation and revised the manuscript for intellectual content. M. Elbejjani, P. Lu, and K. Yaffe revised the manuscript for intellectual content.

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