

# Religious Service Attendance and Lower Depression Among Women—a Prospective Cohort Study

Shanshan Li, ScD<sup>1</sup> · Olivia I Okereke, MD<sup>2,5,6</sup> · Shun-Chiao Chang, ScD<sup>5</sup> · Ichiro Kawachi, PhD<sup>4</sup> · Tyler J. VanderWeele, PhD<sup>2,3,7</sup>

Published online: 8 July 2016  
© The Society of Behavioral Medicine 2016

## Abstract

**Objective** Previous studies on the association between religious service attendance and depression have been mostly cross-sectional, subject to reverse causation, and did not account for the potential feedback between religious service attendance and depression. We prospectively evaluated evidence whether religious service attendance decreased risk of subsequent risk of depression and whether depression increased subsequent cessation of service attendance, while explicitly accounting for feedback with potential effects in both directions. **Method** We included a total of 48,984 US nurses who were participants of the Nurses' Health Study with mean age 58 years and who were followed up from 1996 to 2008. Religious service attendance was self-reported in 1992, 1996, 2000, and 2004. Depression was defined as self-reported physician-diagnosed clinical depression, regular

anti-depressant use, or severe depressive symptoms. Multivariate logistic regression and marginal structural models were used to estimate the odds ratio of developing incident depression, adjusted for baseline religious service attendance, baseline depression, and time-varying covariates. **Results** Compared with women who never attended services, women who had most frequent and recent religious service attendance had the lowest risk of developing depression (odds ratio [OR] = 0.71, 95 % confidence interval [CI] 0.62–0.82). Compared with women who were not depressed, women with depression were less likely to subsequently attend religious services once or more per week (OR = 0.74, 95 % CI 0.68–0.80). **Conclusions** In this study of US women, there is evidence that higher frequency of religious service attendance decreased the risk of incident depression and women with depression were less likely to subsequently attend services.

This work has been previously presented by Dr. VanderWeele at American Public Health Association Annual Meeting, New Orleans, LA, November 15–19, 2014, and the Annual Conference on Religion and Medicine, Cambridge, MA, March 6–8, 2015.

**Electronic supplementary material** The online version of this article (doi:10.1007/s12160-016-9813-9) contains supplementary material, which is available to authorized users.

✉ Tyler J. VanderWeele  
tvanderw@hsph.harvard.edu

<sup>1</sup> Departments of Nutrition, Harvard T. H. Chan School of Public Health, 655 Huntington Avenue, Boston, MA 02115, USA

<sup>2</sup> Department of Epidemiology, Harvard T. H. Chan School of Public Health, 655 Huntington Avenue, Boston, MA 02115, USA

<sup>3</sup> Department of Biostatistics, Harvard T. H. Chan School of Public Health, 655 Huntington Avenue, Boston, MA 02115, USA

<sup>4</sup> Department of Social and Behavioral Sciences, Harvard T. H. Chan School of Public Health, 655 Huntington Avenue, Boston, MA 02115, USA

<sup>5</sup> Department of Medicine, Channing Division of Network Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA 02115, USA

<sup>6</sup> Department of Psychiatry, Harvard Medical School and Brigham and Women's Hospital, Boston, MA 02115, USA

<sup>7</sup> Program on Integrative Knowledge and Human Flourishing, Harvard University, Cambridge, MA 02138, USA

**Keywords** Religious service attendance · Depression · Causal models

## Introduction

Depression is the leading cause of disability worldwide, affecting 350 million people of all ages [1]. Approximately 6.7 % of Americans are currently suffering from some form of depression [1]. Depression is also a major risk factor for suicide [1]. Compared with men, women are 70 % more likely to experience depression over the course of a lifetime. The mechanisms underlying depression are poorly understood, and the standard medications and treatments reduce depressive symptoms by only about 50 % [2]. Biological factors (e.g., genetic risk, medical illness) as well as psychological and/or spiritual factors (e.g., poor coping or resilience, low levels of mindfulness) may contribute to the development of depression [3]. For religious patients, religious practice may constitute a complementary therapy, as it can provide social support and may promote a sense of peace, hope, and meaning in life [4, 5].

Previous studies have suggested a modest inverse association between religious service attendance and depression [6–10]. However, the majority of these studies have had serious methodological limitations. Most research has been based on cross-sectional study designs [11–16], which generally cannot provide evidence of causality. Limited longitudinal research has been carried out [17–20]. Complicating matters further, a recent study by Maselko et al. suggested that onset of major depression in early life (before 18 years of age) is associated with subsequent discontinuation of religious service attendance [21]. Maselko et al. pointed out that if this is so, then cross-sectional studies could find a seemingly protective association between service attendance and depression even if there is no actual effect, simply because those who are depressed stop attending [21]. VanderWeele noted that even longitudinal studies of service attendance and depression suggested a protective effect, but no study had yet adequately addressed the methodological challenge of feedback with potential effects in both directions [22]. Moreover, previous studies have only used one measurement of service attendance which captured “prevalent exposure” instead of “incident exposure.” Previous studies were thus still subject to reverse causation [22]. To the best of our knowledge, no previous study has used repeated measurements of both depression and religious service attendance and has been able to evaluate the potential feedback between religious service attendance and depression.

Using the Nurses’ Health Study (NHS) with repeated measures of service attendance and depression for up to 12 years of follow-up, we investigated the evidence for whether and to what extent (1) religious service attendance is associated with the risk of subsequent depression and (2) depression is associated with subsequent religious service attendance.

## Methods

### Study Design

The Nurses’ Health Study (NHS) included 121,701 nurses aged 30–55 years at baseline, from across the USA, and who were followed up from 1976 to the present [23]. Information on lifestyle and medical history was collected biennially using a self-administered questionnaire. Participants who had depression or religious service attendance information missing in 1992 or 1996 ( $n = 49,037$ ) or died before 2000 ( $n = 3877$ ) were excluded. Compared with the general population, patients with cancer or cardiovascular disease have higher depression risk and might alter their religious service attendance. We, therefore, considered analyses both with and without participants who had a diagnosis of cardiovascular disease or cancer at baseline ( $n = 19,803$ ). In our primary analysis, we included a final sample size of 48,984 NHS participants with mean age of 58 years in 1996 (baseline) and followed up to 2008. The study protocol for the NHS was approved by the institutional review boards of Brigham and Women’s Hospital and Harvard School of Public Health.

### Assessment of Religious Service Attendance

#### *Religious Service Attendance in 1996 and 2000 and Risk of Depression in 2004*

Information on frequency of religious service attendance was self-reported in the 1992, 1996, 2000, 2004, and 2008 questionnaires, with the question “How often in the past year do you attend religious services?” Responses were “more than once per week, once per week, one to three times per month, less than once per month, and never or almost never.” To ensure reasonably large categories, we modeled religious service attendance as four categories: “more than once per week, once per week, less than once per week, and never or almost never (reference group).”

#### *Depression in 1996 and 2000 and Subsequent Religious Service Attendance in 2004*

We also examined associations between depression and subsequent religious service attendance. For the service attendance outcome in these analyses, we used the information reported in 2004 and 2008 questionnaires and modeled it as a binary variable ( $\geq 1/\text{week}$ ,  $< 1/\text{week}$  (reference group)).

## Assessment of Depression

### *Religious Service Attendance in 1996 and 2000 and Risk of Depression in 2004*

In the 2000, 2004, and 2008 questionnaires, study participants self-reported whether they had physician-diagnosed depression. Beginning in 1996, they reported biennially whether they had regular use of antidepressants. Depression measures in 2004 were taken as the primary outcomes. In 2004, participants were given the ten-item version of the Center for Epidemiologic Studies Depression scale (CESD-10). CESD-10 was designed for brief screening and identification of depressive symptoms in the general population (total scores range from 0 to 30), and a cutoff point of 10 is recommended for clinically significant depressive symptoms [24]. As a secondary analysis, depression in 2008 was measured using the Geriatric Depression scale (GDS-15) with 15 items [25, 26]; prior data indicate that a cutoff point of 10 yields a sensitivity of 100 % and a specificity of 84 % [25, 26]; Cronbach alpha coefficients were 0.75, with modest construct validity [26]. Frequently recommended cutoff points for GDS-15 are currently  $\geq 5$  and  $\geq 6$  [25, 27]. We performed the analysis using a cutoff point of  $\geq 6$  points, as unpublished data from an ongoing depression validation study suggested that 6 is the optimal cutoff point when compared to the gold standard of Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV) depression by semi-structured diagnostic interview.

### *Depression in 1996 and 2000 and Subsequent Religious Service Attendance in 2004*

For the association between depression and subsequent religious service attendance, the depression exposure was defined as self-reported physician or clinician-diagnosed depression or Mental Health Index  $\leq 52$ , which was available in the NHS in 1996 and 2000 (yes or no).

## Covariates

We considered a wide range of covariates in our analysis based on evidence from the literature and *prior* subject knowledge. We included sociodemographic, social, lifestyle factors, smoking status, alcohol consumption, post-menopausal hormone use, and health/medical conditions. Physical/functional limitations or disability was defined as having limitations in activities requiring moderate exertion (e.g., climbing a flight of stairs) or having more than moderate limitations in demanding activities (e.g., lifting heavy objects). Covariate information was updated during the follow-up, and for each exposure period, covariates were adjusted for from the questionnaire prior to the exposure assessment. For example, we adjusted

covariates in 1992 for exposure in 1996 and covariates in 1996 for exposure in 2000.

## Statistical Methods

### *Religious Service Attendance in 1996 and 2000 and Risk of Depression in 2004*

Multivariate logistic regression and marginal structural models were used to calculate odds ratios between religious service attendance and risk of depression. The marginal structural models were our primary analysis and explicitly account for feedback between service attendance and depression and allow for the estimation of the effects over time even in the presence of such feedback [28]. They control for time-varying confounding by weighting techniques [28], described below, and were also used to assess the sensitivity of our conclusions to missing covariates and censoring. Specifically, we generated inverse probability weights for the service attendance exposure in 1996 and 2000, trimmed using a 5 % rule, and applied stabilized weights to the marginal structural model [28]. We also fit multivariate logistic regression models for comparison with other literature.

For associations between religious service attendance and risk of depression in 2004, information on service attendance in 1992 was adjusted as a baseline covariate, and service attendance in 1996 and in 2000 was modeled as categorical exposures with never attending as the reference group. To examine the robustness of the association between religious service attendance and depression, we used three definitions for the outcome of depression in 2004: (1) depression (yes or no) defined as self-reported physician or clinician-diagnosed depression, regular antidepressant medication use, or using CES-D-10  $\geq 10$  points; (2) depression (yes or no) defined using only the CES-D-10 cutoff of 10; and (3) depressive symptoms (continuous) measured by CES-D-10 (Table 2). We adjusted for demographic, lifestyle, medical conditions, social support, and physical function limitation covariates measured in 1992 for the 1996 exposure and measured in 1996 for exposure in 2000. We also adjusted for past religious service attendance frequency and depression status. The marginal structural models adjusted for feedback and time-varying confounding by weighting [28]. We also evaluated the joint effects of service attendance in 1996 and 2000 in relation to depression risk. As secondary analyses, we further excluded participants who were depressed at baseline; we also examined the association among all participants including those with cardiovascular disease and cancer and also among Catholics only and among Protestants only and using depression risk in 2008.

To test the robustness of our results, we compared the following: a complete case approach, replacing missing data by a carryforward from the previous questionnaire, and using an inverse probability weighting method with and without

censoring weights to examine the influence of censoring during 1996–2000. We used sensitivity analysis for unmeasured confounding to assess how substantial residual unmeasured confounding would need to be to explain away the observed associations [29].

#### *Depression in 1996 and 2000 and Subsequent Religious Service Attendance in 2004*

Multivariate logistic regression and marginal structural models were used to estimate odds ratios between depression in 1996 and 2000 and subsequent religious service attendance. We performed subgroup analysis among participants with no baseline depression in 1992. Further, to assess robustness of results to censoring, we used several methods including a complete case approach, replacing missing data by a carry forward from previous questionnaire, and an inverse probability weighting method with and without censoring weights.

## Results

### Religious Service Attendance and Risk of Depression

Among 48,984 women at 1996 baseline, 37,114 women reported religious service attendance and 9244 of them attended more than once per week (Table 1). Participants who attended religious services more than once per week drank less, were less likely to be depressed, and were less likely to be a current smoker. In 1996, 6973 (10.5 %) women were depressed and 42,011 (89.5 %) women were depression free (Supplementary Table 1). From 1996 to 2004, 6432 women developed incident depression. Women who attended religious services often had higher Mental Health Index scores (i.e., fewer depressive symptoms) and lower prevalence of self-reported physician or clinician-diagnosed depression (Table 1). In our study, 41 % of women were Catholic and 53 % were Protestant.

Using marginal structural models, compared with women who never or almost never attended religious services in 2000, adjusted odds ratios for depression in 2004 were 0.87 (95 % CI 0.79, 0.97) for women who attended less than once per week, 0.75 (95 % CI 0.67, 0.84) for women who attended weekly, and 0.71 (95 % CI 0.62, 0.82) for women who attended more than once/week (Table 2). There appeared to be a gradient in the estimates of 2000 religious service attendance levels with depression risk in 2004. Service attendance in 1996 did not appear to reduce depression risk beyond the associations with attendance in 2000. Results were similar with different analytic approaches or methods for handling censoring and missing data or different definitions for depression; results were similar from both the logistic regression model and the marginal structural model (data not shown). The results were consistent across three definitions for the

outcome depression in 2004 (Table 2). The results did not substantially change when stratified by Catholic vs. Protestant (Supplementary Table 2). The results were also similar and significant, although slightly attenuated, using 2008 depression outcomes (data not shown).

For an unmeasured confounder to fully explain away the odd ratio estimate of 0.71, the unmeasured confounder would have to both increase the likelihood of service attendance and decrease the likelihood of depression by 2.1-fold, above and beyond the measured confounders. This would constitute relatively substantial confounding; weaker confounding would not be sufficient to explain away the association. For an unmeasured confounder to bring the upper confidence limit of 0.82 for this estimate above 1, the unmeasured confounder would still have to both increase the likelihood of service attendance and decrease the likelihood of depression by 1.7-fold. Results were similar after further excluding participants with physician or clinician-diagnosed depression at baseline and only restricted to incident depression cases (data not shown). Models that included an interaction between religious service attendances in 1996 and 2000 again indicated that more recent service attendance in 2000 was the stronger predictor, but a change in service attendance (either increase or decrease) was associated with somewhat higher risk of depression than continuous attendance (Table 3). Women who attended services frequently in both 1996 and 2000 had the lowest risk of subsequent depression, while women who had frequent attendance in 1996 but never or less than once per week in 2000 had elevated risk for depression (Table 3). Regardless of analytic methods used, more recent frequent religious service attendance was consistently associated with significantly lower risk of depression. The results were similar after including participants who had cardiovascular diseases and cancer and also when restricting the analysis to that population, with slightly larger estimates for that population (Supplementary Table 4). The effect size for service attendance is comparable to or larger than that of most, but not all, of many other risk factors for depression (Supplementary Table 3).

### Depression and Subsequent Religious Service Attendance

Among 48,984 women at baseline, 6973 had Mental Health Index  $\leq 52$ , which was the cutoff point used to define presence of clinical depression. Compared with women who were not depressed, women with depression had lower religious service attendance in 1992 and 1996 (Supplementary Table 1). They were more likely to feel stressed either at work or home, less likely to be currently married, and less likely to be unemployed in the past 2 years (Supplementary Table 1).

Using marginal structural models, compared to women without depression, women who were depressed in 2000 were less likely to attend frequent religious services (once per week

**Table 1** Baseline characteristics of 48,984 Nurses' Health Study participants by frequencies of religious services attending in 1996

	Frequency of religious service attendance			
	Never or almost never ( <i>n</i> = 11,870)	Less than once/week ( <i>n</i> = 7899)	Once/week ( <i>n</i> = 19,974)	More than once/week ( <i>n</i> = 9244)
Age (years)	61.5 (7.0)	61.5 (7.1)	61.5 (7.0)	61.5 (7.0)
Race/ethnicity (%)				
Caucasian	97	97	97	98
African American	1	1	1	1
Other	2	2	2	1
Currently married (%)	73	74	78	77
Nurses' education level (%)				
High school	68	67	71	70
Bachelor	21	22	19	21
Master or above	11	11	9	8
Religious group (%)				
Catholic	29	28	53	40
Protestant	62	63	43	53
Live alone (%)	15	15	13	14
Not employed in last 2 years (%)	37	34	37	40
Number of close friends, continuous	3.2 (1.0)	3.4 (1.0)	3.4 (1.0)	3.5 (1.1)
Have someone close to talk to (yes or no) (%)	92	94	94	95
Self-reported clinician-diagnosed depression in 1996, binary (%) <sup>b</sup>	13	11	10	9
Mental Health Index-5 score in 1996, continuous <sup>a</sup>	78.4 (14.7)	78.9 (13.8)	79.9 (13.2)	81.5 (12.1)
Physical activity, 10 MET h/week	2.04 (2.4)	2.0 (2.4)	1.9 (2.2)	1.9 (2.2)
Weight change since age 18 (kg)	13.2 (26.1)	13.3 (25.9)	13.3 (25.3)	13.6 (25.4)
Alternative Healthy Eating Index 2010, continuous <sup>c</sup>	47.9 (10.5)	47.9 (10.3)	46.9 (10.1)	47.7 (10.1)
Alcohol intake (g/day) (%)				
0	59	58	55	43
<5	28	32	31	26
5.1–15	19	18	17	12
15.4–30	6	5	4	3
>30	6	3	3	2
Smoking status (%)				
Past smoker	45	44	41	35
Current smoker	20	15	11	6
Never smoker	65	59	52	41
Body mass index (BMI) (%)				
<18 kg/m <sup>2</sup>	17	16	17	17
18.1–21 kg/m <sup>2</sup>	32	34	32	32
21.1–23 kg/m <sup>2</sup>	22	24	24	24
23.1–25 kg/m <sup>2</sup>	20	19	19	19
25.1–27 kg/m <sup>2</sup>	4	4	4	5
27.1–30 kg/m <sup>2</sup>	3	2	3	2
30+ kg/m <sup>2</sup>	2	1	1	1
Hypertension (%)	27	27	26	26
High cholesterol (%)	41	42	42	42
Diabetes (%)	3	3	3	3
Have physical/functional limitations (%)	48	48	46	47

<sup>a</sup> Measured by Mental Health Index. Higher score represents less depressive symptoms. Depression was defined as MHI ≤52

<sup>b</sup> Self-reported depression diagnosis or anti-depressant use

<sup>c</sup> Higher Alternative Healthy Eating Index 2010 (AHEI2010) represents better diet quality

or more) in 2004, with adjusted OR = 0.74 (95 % CI 0.68, 0.80) (Table 4). Results were similar across religious service attendance outcomes in 2004 and 2008; results were similar in logistic regression models, but the magnitude of the odds ratios was smaller when accounting for missing data and censoring (data not shown). For depression, there was also some evidence for an effect of depression in 1996 lowering the likelihood of subsequent service attendance (OR = 0.91; 95 % CI 0.83, 1.00) beyond the effects of depression in 2000.

## Discussion

In this prospective cohort study, with repeated measurements of religious service attendance and depression, women with more frequent service attendance had lower risk of incident depression. Women with depression were subsequently less likely to attend religious services compared with those who were not depressed. Results were robust across different years of service attendance, different analytic methods, accounting

**Table 2** Multivariate associations between religious service attendances in 1996 and 2000 with subsequent onset of depression in 2004

		Marginal structural model						
		Depression <sup>a</sup>		Presence of severe depressive symptoms <sup>b</sup>		Continuous level of depressive symptoms <sup>c</sup>		
		Odds ratios	95 % CI	Odds ratios	95 % CI	Estimate	Std Err	P value
Religious service attendance in 1996								
Never	Reference			Reference		Reference	Reference	Reference
<1/week	1.00	0.89, 1.12		1.04	0.91, 1.19	0.03	0.09	0.70
1/week	1.09	0.95, 1.24		1.12	0.95, 1.30	0.11	0.10	0.27
>1/week	1.15	0.98, 1.36		1.18	0.98, 1.43	0.12	0.12	0.29
Religious service attendance in 2000								
Never	Reference			Reference		Reference	Reference	Reference
<1/week	0.87	0.79, 0.97		0.87	0.77, 0.98	-0.20	0.08	0.01
1/week	0.75	0.67, 0.84		0.72	0.63, 0.82	-0.48	0.09	<0001
>1/week	0.71	0.62, 0.82		0.65	0.55, 0.76	-0.53	0.10	<0001

Multivariate model adjusted for age (years), baseline depressive symptom in 1992 (continuous), baseline religious service attendance in 1992 (never, less than once/week, once/week, more than once/week), live alone (yes, no), not employed in the past 2 years (yes, no), marital status (currently married, yes, no), nurses' education level (high school, bachelor, master), husband education level (under high school, high school graduate, college or above), postmenopausal hormone use (never, current, past), race/ethnic groups (Caucasian, African American, Asian, Hispanic, others), geographic region (middle, north, south), census tract level median family income (dollars per year, continuous), height (continuous), family history of myocardial infarction (yes, no), family history of cancer (yes, no), family history of diabetes (yes, no), body mass index (BMI, <18, 18.1–21, 21.1–23, 23.1–25, 25.1–27, 27.1–30, >30+ kg/m<sup>2</sup>), weight change since age 18 (kg), physical activity (MET h/week), hypertension (yes, no), hypercholesterolemia (yes, no), diabetes (yes, no), diet quality (Alternative Healthy Eating Index 2010, continuous), alcohol consumption (0, <5, 5.1–15, 15.4–30, >30 g/day), number of close friends (continuous), have someone close to talk to (yes, no), smoking status (never, current, past), and physical/functional limitations (yes, no). Marginal structural model with weights accounted for censoring and missing data

CI confidence interval

<sup>a</sup> Binary variable of depression: defined as participants who either self-reported a physician or clinician-diagnosed depression or use of antidepressant medications or CESD-10  $\geq 10$

<sup>b</sup> Binary CESD-10 binary ( $\geq 10$ ). Measured by CESD-10. Higher score represents more depressive symptoms. Total score ranges from 0 to 30. Depression was defined as CESD-10  $\geq 10$

<sup>c</sup> CESD-10 continuous. Measured by CESD-10. Higher score represents more depressive symptoms. Total score ranges from 0 to 30.

for feedback, missing data, and censoring. Our results provide evidence for potential effects in both directions with effect sizes of roughly equal magnitude. Our conclusions are consistent with previous results and, moreover, provide evidence of effects in both directions.

Religiosity is multidimensional, and different aspects of religion and spirituality may therefore be associated with depression differently. In our study, we only have one domain measure of religiosity or spirituality, namely, service attendance. Our study did not measure spirituality and other dimensions of a person's religiosity. Further, frequency of religious service attendance is also a form of social participation and social engagement and closely related to social support. In our study, we attempted to capture religious service attendance in everyday life in our primary analysis by excluding women with chronic diseases or comorbidities at baseline since these conditions may alter patterns of religious service attendances. However, results were similar also when they were included.

Measurement error is also inevitable in self-reported religious service attendance. However, previous studies suggest

that service attendance is often overreported [30], which might lead to an underestimation of effects. Overreporting might also still preserve relative ordering. Depression was measured using different validated questionnaires for 1996, 2000, 2004, and 2008. In our study, prevalence of depression may be misclassified due to the potential of under-detection/under-treatment for depression and under-diagnosis of depression. However, regardless of the different measures for depression, our results were robust and consistent. To separate out new cases with persistent or unremitted depression, we further excluded depression cases at baseline and only evaluated incident depression. Although we adjusted for major confounders for the association between religious service attendance and depression, our study is an observational study and may still be subject to unmeasured confounders and residual confounding. However, for an unmeasured confounder to fully explain away the association of service attendance with subsequent depression, it would have to both increase the likelihood of service attendance and decrease the likelihood of depression by 2.1-fold, above and beyond the measured covariates, which

**Table 3** Transitions in religious service attendance in 1996 and 2000 with subsequent onset of depression in 2004

Religious service attendance	Marginal structural model						
	Depression <sup>a</sup>		Presence of severe depressive symptoms <sup>b</sup>		Continuous level of depressive symptoms <sup>c</sup>		
	Odds ratios	95 % CI	Odds ratios	95 % CI	Estimate	Std Err	P value
<1/week in 1996 and never in 2000	Reference		Reference		Reference	Reference	Reference
<1/week in 1996 and <1/week in 2000	0.87	0.78, 0.96	0.86	0.76, 0.98	-0.21	0.08	0.01
<1/week in 1996 and 1/week in 2000	0.90	0.77, 1.05	0.80	0.67, 0.97	-0.31	0.12	0.01
<1/week in 1996 and >1/week in 2000	0.99	0.70, 1.39	1.18	0.81, 1.73	0.14	0.32	0.65
≥ 1/week in 1996 and never in 2000	1.33	1.09, 1.62	1.24	0.98, 1.57	0.30	0.18	0.09
≥ 1/week in 1996 and <1/week in 2000	1.05	0.91, 1.22	1.05	0.88, 1.24	0.02	0.11	0.88
≥ 1/week in 1996 and 1/week in 2000	0.82	0.72, 0.92	0.79	0.69, 0.91	-0.38	0.09	<0001
≥ 1/week in 1996 and >1/week in 2000	0.80	0.70, 0.92	0.71	0.61, 0.84	-0.44	0.10	<0001

Higher score represents more depressive symptoms. Total score ranges from 0 to 30. Depression was defined as CESD-10  $\geq 10$ . Multivariate model adjusted for age (years), baseline depressive symptom in 1992 (continuous), baseline religious service attendance in 1992 (never, less than once/week, once/week, more than once/week), live alone (yes, no), not employed in the past 2 years (yes, no), marital status (currently married, yes, no), nurses' education level (high school, bachelor, master), husband education level (under high school, high school graduate, college or above), postmenopausal hormone use (never, current, past), race/ethnic groups (Caucasian, African American, Asian, Hispanic, other), geographic region (middle, north, south), census tract level median family income (dollars per year, continuous), height (continuous), family history of myocardial infarction (yes, no), family history of cancer (yes, no), family history of diabetes (yes, no), body mass index (BMI, <18, 18.1–21, 21.1–23, 23.1–25, 25.1–27, 27.1–30, >30+ kg/m<sup>2</sup>), weight change since age 18 (kg), physical activity (MET h/week), hypertension (yes, no), hypercholesterolemia (yes, no), diabetes (yes, no), diet quality (Alternative Healthy Eating Index 2010, continuous), alcohol consumption (0, <5, 5.1–15, 15.4–30, >30 g/day), number of close friends (continuous), have someone close to talk to (yes, no), smoking status (never, current, past), and physical/functional limitations (yes, no). Marginal structural model with weights accounted for censoring and missing data

<sup>a</sup> Binary variable of depression: defined as participants who either self-reported a physician or clinician-diagnosed depression or use of antidepressant medications or CESD-10  $\geq 10$

<sup>b</sup> Binary CESD-10 binary ( $\geq 10$ ). Measured by CESD-10. Higher score represents more depressive symptoms. Total score ranges from 0 to 30. Depression was defined as CESD-10  $\geq 10$

<sup>c</sup> CESD-10 continuous. Measured by CESD-10. Higher score represents more depressive symptoms. Total score ranges from 0 to 30.

may not be likely. In our study, we did not inquire about potential mediating mechanisms. All covariates that we adjusted for in our analyses were measured in the period prior to the exposure and thus would not be mediators. Future

studies are needed to investigate potential underlying mediating mechanisms between religious service attendance and depression and also to better assess the effects of other measures of religiosity than frequency of religious service attendance.

**Table 4** Multivariate associations between depression in 1996 and 2000 and subsequent frequent religious service attendance ( $\geq 1$ /week) in 2004 and 2008

Follow-up period		Religious service attendance ( $\geq 1$ /week) in 2004		Religious service attendance ( $\geq 1$ /week) in 2008	
		1996–2004 Odds ratio	95 % CI	1996–2008 Odds ratio	95 % CI
Depression in 1996	No	Reference		Reference	
	Yes	0.91	0.83, 1.00	0.91	0.83, 1.00
Depression in 2000	No	Reference		Reference	
	Yes	0.74	0.68, 0.80	0.75	0.69, 0.82

Multivariate model adjusted for age (years), baseline depressive symptom in 1992 (continuous), baseline religious service attendance in 1992 (never, less than once/week, once/week, more than once/week), live alone (yes, no), not employed in the past 2 years (yes, no), marital status (currently married, yes, no), nurses' education level (high school, bachelor, master), husband education level (under high school, high school graduate, college or above), postmenopausal hormone use (never, current, past), race/ethnic groups (Caucasian, African American, Asian, Hispanic, others), geographic region (middle, north, south), census tract level median family income (dollars per year, continuous), height (continuous), family history of myocardial infarction (yes, no), family history of cancer (yes, no), family history of diabetes (yes, no), body mass index (BMI, <18, 18.1–21, 21.1–23, 23.1–25, 25.1–27, 27.1–30, >30+ kg/m<sup>2</sup>), weight change since age 18 (kg), physical activity (MET h/week), hypertension (yes, no), hypercholesterolemia (yes, no), diabetes (yes, no), diet quality (Alternative Healthy Eating Index 2010, continuous), alcohol consumption (0, <5, 5.1–15, 15.4–30, >30 g/day), number of close friends (continuous), have someone close to talk to (yes, no), smoking status (never, current, past), and physical/functional limitations (yes, no). Marginal structural model with weights accounted for censoring and missing data

Religiosity and spirituality vary greatly in style and content across different cultures and race/ethnicity groups. The strengths of the association between religiosity and health may differ across gender, race/ethnicity, and different forms of religiosity. Our study mainly consisted of White Christians and consisted entirely of US women who were nurses. In this study, about 90 % reported being Protestant or Catholic. The health-related behaviors of nurses may differ from the general population. Our results might not be generalizable to other race/ethnicity group and demographic groups with other religious beliefs. Individuals suffering from depression tend to withdraw from all types of social activities, and patterns may differ with other chronic diseases. However, the extensive confounding adjustment and robustness of our results to different analytic approaches help ensure the internal validity of our study.

Our study findings do not imply that physicians should prescribe religious service recommendations for patients. The ethical questions are of course complex. However, for patients who are already religious, service attendance might be encouraged as a form of meaningful social participation to alleviate depression. Somewhat paradoxically, however, persons with depression are more likely to cease attending. Further study of this phenomenon merits attention. The results may also be of interest to religious communities in that those who become depressed tend to cease attendance, which may exacerbate depression further. Further support could be extended to such persons before they leave. It may, moreover, be important for psychiatrists, physicians, and other health care providers to be aware of and take into account the potential role of faith and belief in depression prevention and treatment.

The strengths of our study included the large sample size, repeated measures on service attendance and depression, and analytic methods accounting for feedback. To the best of our knowledge, no previous study had examined incident rather than prevalent religious service attendance, the latter of which could still be subject to reverse causation, as depression onset during adulthood may lead to a lower level of religious service attendance in later life. By using marginal structural models, we have been able to tease out the feedback between religious service attendance and depression and appropriately account for reverse causation and time-dependent confounding. We also have clear temporality of covariates, exposure, and outcome. Using validated questionnaires, we adjusted for lifestyle, medical history, and a wide range of potential confounders, along with baseline exposure, baseline outcome, and time-varying covariates.

In conclusion, based on a large longitudinal cohort study with repeated measures of religious service attendance and depression, we found evidence that women with a higher level of religious service attendance were less likely to develop depression, and women who were depressed were less likely to attend religious services frequently.

**Acknowledgments** The study was supported by the Templeton Foundation and National Institutes of Health grant R01 ES017876. The funding agencies played no role in the design and conduct of this study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

**Authors' Contribution** SL and TJV contributed to the study design, data analysis, interpretation, and manuscript preparations. OIO, S-C C, and IK contributed to the study design and critical review of the manuscript. SL and TJV had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

**Authors' Statement of Conflict of Interest and Adherence to Ethical Standards** Authors Shanshan Li, Olivia I Okereke, Shun-Chiao Chang, Ichiro Kawachi, and Tyler J. VanderWeele declare that they have no conflict of interest. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

## References

1. Brundtland GH. From the World Health Organization. Mental health: new understanding, new hope. *JAMA*. 2001;286(19): 2391.
2. Blackburn–Munro G. Hypothalamo–pituitary–adrenal axis dysfunction as a contributory factor to chronic pain and depression. *Curr Pain Headache Rep*. 2004;8(2): 116–24.
3. Koenig HG. Religion, spirituality, and health: a review and update. *Adv Mind Body Med*. 2015;29(3): 19–26.
4. VanderWeele TJ. Religion and health: A synthesis. In: Peteet, JR and Balboni, MJ eds. *Spirituality and Religion within the Culture of Medicine: From Evidence to Practice*. New York, NY: Oxford University Press; 2016.
5. Mytko JJ, Knight SJ. Body, mind and spirit: towards the integration of religiosity and spirituality in cancer quality of life research. *Psycho-oncology*. 1999;8(5): 439–50.
6. Koenig HG. Depression in chronic illness: does religion help? *J Christ Nurs Q Publ Nurs Christ Fellowship*. 2014;31(1): 40–6.
7. McCullough ME, Larson DB. Religion and depression: a review of the literature. *Twin Res*. 1999;2(2): 126–36.
8. Hayward RD, Owen AD, Koenig HG, Steffens DC, Payne ME. Longitudinal relationships of religion with posttreatment depression severity in older psychiatric patients: evidence of direct and indirect effects. *Depress Res Treat*. 2012;745970.
9. Koenig HG. Religion and depression in older medical inpatients. *Am J Geriatr Psychiatry*. 2007;15(4): 282–91.
10. Koenig HG, Hays JC, George LK, Blazer DG, Larson DB, Landerman LR. Modeling the cross-sectional relationships between religion, physical health, social support, and depressive symptoms. *Am J Geriatr Psychiatry*. 1997;5(2): 131–44.
11. Rasic D, Kisely S, Langille DB. Protective associations of importance of religion and frequency of service attendance with depression risk, suicidal behaviours and substance use in adolescents in Nova Scotia, Canada. *J Affect Disord*. 2011;132(3): 389–95.
12. King DA, Lyness JM, Duberstein PR, He H, Tu XM, Seaburn DB. Religious involvement and depressive symptoms in primary care elders. *Psychol Med*. 2007;37(12): 1807–15.
13. Chatters LM, Bullard KM, Taylor RJ, Woodward AT, Neighbors HW, Jackson JS. Religious participation and DSM–IV disorders among older African Americans: findings from the National Survey of American Life. *Am J Geriatr Psychiatry*. 2008;16(12): 957–65.



14. Agorastos A, Demiralay C, Huber CG. Influence of religious aspects and personal beliefs on psychological behavior: focus on anxiety disorders. *Psychol Res Behav Manag.* 2014;7: 93–101.
15. Maselko J, Gilman SE, Buka S. Religious service attendance and spiritual well-being are differentially associated with risk of major depression. *Psychol Med.* 2009;39(6): 1009–17.
16. Koenig HG, McCullough ME, Larson DB. *Handbook of Religion and Health.* Oxford; New York Oxford University Press; 2001.
17. Koenig HG, George LK, Peterson BL. Religiosity and remission of depression in medically ill older patients. *Am J Psychiatry.* 1998;155(4): 536–42.
18. Barton YA, Miller L, Wickramaratne P, Gameroff MJ, Weissman MM. Religious attendance and social adjustment as protective against depression: a 10-year prospective study. *J Affect Disord.* 2013;146(1): 53–7.
19. Barton YA, Miller L, Wickramaratne P, Gameroff MJ, Weissman MM. Religiosity and major depression in adults at high risk: a ten-year prospective study. *Am J Psychiatry.* 2012;169(1): 89–94.
20. Rasic D, Asbridge M, Kisely S, Langille D. Longitudinal associations of importance of religion and frequency of service attendance with depression risk among adolescents in Nova Scotia. *Can J Psychiatry.* 2013;58(5): 291–9.
21. Maselko J, Hayward RD, Hanlon A, Buka S, Meador K. Religious service attendance and major depression: a case of reverse causality? *Am J Epidemiol.* 2012;175(6): 576–83.
22. VanderWeele TJ. Re: “Religious service attendance and major depression: a case of reverse causality?” *Am J Epidemiol.* 2013;177(3): 275–6.
23. Belanger CF, Hennekens CH, Rosner B, Speizer FE. The Nurses’ Health Study. *Am J Nurs.* 1978;78(6): 1039–40.
24. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). *Am J Prev Med.* 1994;10(2): 77–84.
25. Lyness JM, Noel TK, Cox C, King DA, Conwell Y, Caine ED. Screening for depression in elderly primary care patients. A comparison of the center for epidemiologic studies–depression scale and the geriatric depression scale. *Arch Intern Med.* 1997; 157(4): 449–54.
26. Friedman B, Heisel MJ, Delavan RL. Psychometric properties of the 15-item geriatric depression scale in functionally impaired, cognitively intact, community-dwelling elderly primary care patients. *J Am Geriatr Soc.* 2005;53(9):1570–6.
27. Blank K, Gruman C, Robison JT. Case-finding for depression in elderly people: balancing ease of administration with validity in varied treatment settings. *J Gerontol Ser A Biol Sci Med Sci.* 2004;59(4): M378–M84.
28. Robins JM, Hernan MA, Brumback B. Marginal structural models and causal inference in epidemiology. *Epidemiology* (Cambridge, Mass.). 2000;11(5):550–560.
29. Ding P, and VanderWeele TJ. Sensitivity analysis without assumptions. *Epidemiology.* 2016;27(3):368–377.
30. Hadaway CK, Marler PL, Chaves M. What the polls don’t show: a closer look at U.S. Church attendance. *Am Sociol Rev.* 1993;58: 741–52.