

BMJ Open Does religious involvement affect mortality in low-income Americans? A prospective cohort study

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ABSTRACT

Objective This study aimed to evaluate the impacts of various forms of religious involvement, beyond individual socioeconomic status, lifestyle factors, emotional well-being and social support, on all-cause and cause-specific mortality in socioeconomic disadvantaged neighbourhoods.

Design This is a prospective cohort study conducted from 2002 through 2015.

Settings This study included underserved populations in the Southeastern USA.

Participants A total of nearly 85 000 participants, primarily low-income American adults, were enrolled. Eligible participants were aged 40–79 years at enrolment, spoke English and were not under treatment for cancer within the prior year.

Results We found that those who attended religious service attendance >1/week had 8% reduction in all-cause death and 15% reduction in cancer death relative to those who never attended. This association was substantially attenuated by depression score, social support, and socioeconomic and lifestyle covariates, and further attenuated by other forms of religious involvement. This association with all-cause mortality was found being stronger among those with higher socioeconomic status or healthier lifestyle behaviours.

Conclusion Our results indicate that the association between religious services attendance >1/week and lower mortality was moderate but robust, and could be attenuated and modified by socioeconomic or lifestyle factors in this large prospective cohort study of underserved populations in the Southeastern USA.

INTRODUCTION

A large and growing body of literature has related religious involvement to better health outcomes. In particular, several previous studies suggested that frequent religious service attendance was associated with decreased mortality.^{1–12} A study with a national sample reported that individuals who report attending religious services once a month or more had a 30%–35% reduced risk of death over a 7.5-year follow-up period after adjusting for potential confounding factors.³ A recent prospective cohort study reported similar findings, noting that after

Strengths and limitations of this study

- The data for this study were obtained from a large-scale prospective cohort study, the Southern Community Cohort Study (SCCS) in underserved populations in the Southeastern USA.
- This cohort presents a unique opportunity to evaluate the impacts of various forms of religious involvement, beyond individual socioeconomic status, lifestyle factors, emotional well-being and social support, on all-cause and cause-specific mortality in socioeconomic disadvantaged neighbourhoods.
- Most of the SCCS participants were recruited at community health centres, which were not representative of the general US southern population.
- We did not collect the data on religious coping, religious affiliation and other aspects of religion and spiritual, which might affect mortality differently.

multivariable adjustment for major lifestyle factors and other risk factors, women who had attended a religious service more than once per week experienced 33% lower all-cause mortality compared with women who had never attended religious services.⁷

The association between more frequent religious service attendance and lower mortality appears to be robust.¹¹ Religious involvement is frequently associated with multiple community-level socioeconomic factors, such as rural/urban residence and neighbourhood; personal demographic factors, such as race, gender and socioeconomic status; personal lifestyle factors, such as smoking, alcohol drinking, diet and physical activity; psychological factors, such as less depression; and interpersonal factors such as more social support.^{6 13 14} All of these factors are independently known to be risk or protective factors for premature mortality. There is considerable evidence that the association between religious involvement, including religious service attendance, and health is mediated by health behaviours, social support and positive emotions.^{11 15}

Attendance at religious services is only one aspect of the current conception of religion and spirituality and its relationship to health.⁶ The association of religious service attendance with mortality may involve other elements of religion/spirituality or the association may be mediated by the aforementioned psychosocial variables and confounded with the social determinants of health.¹⁶ Few previous studies were able to collect data for all of these factors and analyse them in one statistical model to elucidate their effects.

According to the Gallop Daily tracking interviews throughout 2014 with 177 030 US adults,¹⁷ 10 of the 12 states with the highest self-reported religious service attendance are in the South, where the ongoing Southern Community Cohort Study (SCCS) recruited primarily low-income black and white adults as participants, with about two-thirds of the participants being black. While there are studies investigating the relationship between religious involvement and mortality in minority populations, most work has been done with small numbers of black participants.^{12 18 19} Religion and participation in the church is an important part of African-American communities,²⁰ with typically higher levels of participation than in non-Hispanic white communities.^{21 22}

The SCCS is unique in that the majority of participants were recruited from community health centres (CHCs) in urban and rural settings in the Southern USA. The cohort consists largely of individuals with low income and a high school education or less.^{23 24} The differences in demographic characteristics, health conditions and risky behaviours between African-Americans and other racial and ethnic groups is less in the SCCS than in more population representative samples.^{24 25} This cohort presents a unique opportunity to replicate the importance of church attendance as a predictor of all-cause mortality in a prospective cohort that includes a large number of African-Americans. In addition to controlling for behavioural, interpersonal and emotional mediators, the SCCS also includes a measure of neighbourhood disadvantage.

The aim of this study was to examine the associations of all-cause mortality and cause-specific mortality with multiple aspects of religious involvement including religious service attendance, spirituality and personal importance of religion using the unique SCCS data.

METHODS

Study population

The SCCS is a prospective cohort study designed to investigate cancer and other chronic diseases in underserved populations in the Southeastern USA.^{23–27} A total of nearly 85 000 participants were enrolled into the SCCS between March 2002 and September 2009. Approximately 86% of participants were recruited at CHCs. CHC network provided a mean to reach persons of low socioeconomic status from rural and urban areas in the southern USA who would be extremely difficult to reach

by other means. While not being broadly representative of southern blacks, CHCs capture a group that makes up a sizeable minority of that population and a group that is at especially high risk for premature morbidity and mortality.²³ The remaining 14% were recruited by randomised general population mailing. Eligible participants were aged 40–79 years at enrolment, spoke English and were not under treatment for cancer within the prior year. Detailed description of SCCS methods has been previously published.^{23–27} The study was approved by the Institutional Review Boards at Vanderbilt University and Meharry Medical College. All participants provided written informed consent.

Ascertainment of risk factors

Demographic, socioeconomic, lifestyle and anthropometric data, as well as personal medical history, were ascertained at cohort enrolment via standardised computer-assisted personal interviews for CHC participants and via self-administered mailed questionnaires for persons recruited from the general population. SCCS participants reported their highest level of education attained and the range of their total household income for the year prior to enrolment. History of tobacco smoking was self-reported as never, former and current, and alcohol use was reported in number of drinks per day. A summary variable for physical activity was created as the sum of all household, leisure and occupational activity over the course of a week to reflect per day activity and converted to metabolic equivalent estimates of energy expenditure using methods described in the Compendium of Physical Activities.²⁸ To assess diet quality, Healthy Eating Index (HEI) values (range 0–100) were calculated, where a higher value indicated a healthier diet, based on 12 dietary components.^{29 30} The presence of common chronic diseases including hypertension, diabetes, heart attack, high cholesterol, stroke, chronic obstructive pulmonary disease (COPD), depression and cancer at baseline interview was based on a self-reported history. The comorbidity index (range 0–12) based on the Charlson index^{31 32} was calculated for each cohort member based on diseases reported on the baseline questionnaire.

We used the 2003 Rural-Urban Continuum Codes as a community-level variable to distinguish metropolitan counties by the population size of their metro area, and non-metropolitan counties by degree of urbanisation and adjacency to a metro area. Each county in the USA is assigned one of the nine codes, which include three metro and six non-metro categories.

To more accurately assess the economic and social diversity of American populations, we further used the SCCS-derived neighbourhood deprivation index as a clustering of social and economic indicators which reflect neighbourhood socioeconomic environment and have been linked to adverse health outcomes. Briefly, the index was constructed through principal component analysis and incorporates 11 census tract-level variables that capture five domains including education, employment,

housing, occupation and poverty, described in more detail in our previous publication.²⁶ The variables were obtained from the 2000 US census data³³ and linked to the geographical coordinates of residential addresses for each participant.³⁴

Religious involvement was self-reported at baseline interview. The questionnaire asked three aspects of religious involvement, 'How often do you attend religious or faith services during the year' to measure the frequency of religious service attendance; 'How spiritual or religious do you consider yourself to be' to measure the spirituality; and 'How much is religion, faith, or God a source of strength and comfort to you' to measure the personal importance of religion.

Information on emotional well-being was collected via the 10-item CES-D (Centre for Epidemiologic Studies Depression Scale) for depression and two questions (you were unable to control the important things in your life? Difficulties were piling up so high that you could not overcome them?) for personal stress. Social support was measured with the score from two questions (How many close friends or relatives would help you with your emotional problems or feelings if you needed it? How many people could you ask for help in an emergency or with lending you money?)

Outcome ascertainment

Vital status was obtained via linkage to the Social Security Administration's Death Master File. Cause of death was ascertained from the National Death Index through 31 December 2015, when the most up-to-date death index data were available. Cause-specific mortality categories were grouped according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) codes and were classified as cardiovascular diseases (CVD, I00–I69), cancer (C00–C97) and all other causes. The outcome information was obtained virtually for all participants.

Statistical analysis

There were 5.8% missing values for HEI and 0.3%–2.4% missing values for some other covariates. The missing values of these covariates were first imputed using the multivariate imputation by chained equations³⁵ to preserve the data. We then examined the medians and IQR of the continuous covariates and frequencies of categorical covariates by religious service attendance. As religious service attendance is an ordinal variable, we used the proportional odds model³⁶ to evaluate the overall association between the selected covariates and religious service attendance.

For the current analyses, the data were organised in a hierarchical fashion comprising two levels with individual participants (level 1 units) nested within community level variables, 2003 Rural-Urban Continuum Codes and the neighbourhood deprivation index. Given the non-independence of the data points within the nested data structure, we used a Cox proportional hazards model that

accounts for non-independence using the Huber-White cluster sandwich estimator of variance³⁷ to analyse the association of religious involvement with all-cause and cause-specific mortality.

We used age as the timescale in the Cox regression model. The proportional hazards assumption was evaluated with Schoenfeld residuals. We used the stratified Cox model to treat the predictors that did not satisfy the proportional hazards assumption.

Patient involvement

No patients were involved in developing the research question or the outcome measures, nor were they involved in planning the design, recruitment to and conduct of the study. No patients were asked to advise on the interpretation or writing up of results. There are no plans to disseminate the results of the research to study participants.

RESULTS

The current analysis included 82510 participants who provided information on vital status, socioeconomic and lifestyle factors, religious involvement, emotional well-being and social support. The median follow-up time was 10.25 years. During the follow-up, we observed 14325 all-cause deaths, 3509 cancer deaths, 4473 CVD deaths and 5186 other deaths.

The majority of the cohort was African-American (65%), had household income <US\$15000 (55%) at baseline and did not have educational attainment beyond high school (61%). Men were less likely than women to attend religious services, so were whites than blacks. All of the beneficial socioeconomic status (higher education levels and household income) and lifestyle factors (less tobacco smoking, less alcohol drinking, more physical activity and higher HEI scores) were associated with higher religious services attendance (table 1). All of the ORs shown in table 1 were highly significant at $p < 0.01$, except for ORs for body mass index (BMI) and comorbidity index, which were not statistically significant after adjustment.

In table 2, we show associations of risk factors of interest with all-cause mortality from three different models. The covariates included in model 1 were basic demographic and socioeconomic variables, BMI, common chronic diseases at the baseline interview, insurance coverage (yes/no), enrolment source (in-person/mail/telephone interview), 2003 Rural-Urban Continuum codes and the SCCS-derived neighbourhood deprivation index. Based on model 1, more frequent religious service attendance, the highest level of spirituality and personal importance of religion, lower score for depression and personal stress, higher score for social support were significantly associated with lower all-cause mortality.

In addition to the covariates included in the model 1, we included potential mediators (smoking status, number of alcohol drinks per week, physical activity, and HEI, depression score or personal stress, and social support) in model 2 for adjustment. Depression score and personal

Table 1 Characteristics of the SCCS participants at the baseline in 2002–2009, by religious service attendance

Categorical	Religious service attendance				OR (95% CI)*
	Never	<1/week	1/week	>1/week	
	(n=12 759) n (%)	(n=28 635) n (%)	(n=21 482) n (%)	(n=19 634) n (%)	
Gender					
Women	6480 (13.2)	15 991 (32.7)	13 471 (27.5)	13 016 (26.6)	Reference
Men	6279 (18.7)	12 644 (37.7)	8011 (23.9)	6618 (19.7)	0.87 (0.85 to 0.90)
Race					
White	6950 (27.6)	8053 (32.0)	5337 (21.2)	4823 (19.2)	Reference
Black	5082 (9.4)	19 492 (36.1)	15 358 (28.5)	14 048 (26.0)	2.54 (2.46 to 2.63)
Other	727 (21.6)	1090 (32.4)	787 (23.4)	763 (22.7)	1.36 (1.27 to 1.46)
Education					
<High school	4263 (18.1)	8725 (37.1)	5987 (25.5)	4530 (19.3)	Reference
High school	4212 (15.6)	9779 (36.2)	6966 (25.8)	6081 (22.5)	1.20 (1.16 to 1.24)
>High school	4284 (13.4)	10 131 (31.7)	8529 (26.7)	9023 (28.2)	1.44 (1.39 to 1.49)
Income, US\$					
<15 000	7523 (16.7)	16 915 (37.5)	11 279 (25.0)	9428 (20.9)	Reference
<25 000	2344 (13.5)	6016 (34.6)	4611 (26.5)	4400 (25.3)	1.06 (1.02 to 1.09)
≥25 000	2892 (14.5)	5704 (28.5)	5592 (28.0)	5806 (29.0)	1.19 (1.14 to 1.24)
Marital status					
Married	4565 (15.5)	9019 (30.6)	7788 (26.4)	8080 (27.4)	Reference
Divorced	4432 (16.1)	10 219 (37.1)	6966 (25.3)	5935 (21.5)	0.87 (0.84 to 0.90)
Widowed	893 (11.1)	2341 (29.1)	2401 (29.8)	2410 (30.0)	1.08 (1.02 to 1.13)
Single	2869 (16.4)	7056 (40.4)	4327 (24.8)	3209 (18.4)	0.76 (0.74 to 0.79)
Insurance coverage					
No	5440 (16.9)	12 527 (39.0)	7563 (23.6)	6580 (20.5)	Reference
Yes	7319 (14.5)	16 108 (32.0)	13 919 (27.6)	13 054 (25.9)	1.04 (1.01 to 1.07)
Smoking status					
Never	3082 (10.3)	8529 (28.6)	8998 (30.2)	9209 (30.9)	Reference
Former	2972 (15.5)	5611 (29.3)	4984 (26.0)	5566 (29.1)	0.92 (0.89 to 0.95)
Current	6705 (20.0)	14 495 (43.2)	7500 (22.3)	4859 (14.5)	0.61 (0.59 to 0.63)
Alcohol drinking					
0 drink/day	4949 (12.8)	10 349 (26.8)	10 836 (28.0)	12 544 (32.4)	Reference
one drink/day	4261 (16.2)	10 351 (39.3)	6831 (25.9)	4887 (18.6)	0.57 (0.55 to 0.59)
>1 drinks/day	3549 (20.3)	7935 (45.3)	3815 (21.8)	2203 (12.6)	0.47 (0.46 to 0.49)
Physical activity (MET-h/day)					
<10	4027 (19.4)	7160 (34.6)	5178 (25.0)	4347 (21.0)	Reference
10–20	3091 (14.5)	7101 (33.3)	5825 (27.4)	5278 (24.8)	1.18 (1.14 to 1.23)
20–30	2577 (13.6)	6368 (33.7)	4977 (26.3)	4988 (26.4)	1.25 (1.21 to 1.30)
>30	3064 (14.2)	8006 (37.1)	5502 (25.5)	5021 (23.3)	1.33 (1.28 to 1.38)
Continuous	Median (Q1, Q3)†	Median (Q1, Q3)	Median (Q1, Q3)	Median (Q1, Q3)	OR (95% CI)*, ‡
Age	51.3 (45.8, 58.1)	50.0 (45.0, 56.3)	52.1 (46.2, 59.3)	52.9 (46.8, 60.5)	1.10 (1.07 to 1.13)
Depression score	9.0 (5.0, 15.0)	8.0 (5.0, 13.0)	7.0 (4.0, 12.0)	6.0 (3.0, 11.0)	0.80 (0.78 to 0.82)
Personal stress	4.0 (2.0, 5.0)	3.0 (2.0, 5.0)	3.0 (2.0, 4.0)	3.0 (2.0, 4.0)	0.95 (0.94 to 0.97)
Social support	4.0 (3.0, 6.0)	4.0 (3.0, 6.0)	5.0 (3.0, 7.0)	5.0 (4.0, 8.0)	1.30 (1.27 to 1.33)
HEI	54.0 (46.0, 62.8)	55.6 (48.0, 63.9)	58.8 (50.5, 67.2)	60.6 (52.0, 69.3)	1.26 (1.23 to 1.28)

Continued

Table 1 Continued

Categorical	Religious service attendance				OR (95% CI)*
	Never	<1/week	1/week	>1/week	
	(n=12759)	(n=28635)	(n=21482)	(n=19634)	
	n (%)	n (%)	n (%)	n (%)	
BMI	28.2 (24.1, 33.6)	28.5 (24.4, 33.7)	29.2 (25.1, 34.5)	30.0 (25.8, 35.4)	1.00 (0.98 to 1.02)
Comorbidity index	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)	1.00 (0.98 to 1.02)

*The ORs (95% CIs) were derived from the proportional odds model by treating the religious service attendance as an ordinal variable. The ORs were adjusted for basic demographic and socioeconomic variables (age at enrolment, gender, race, marital status, education levels, household income), insurance coverage (yes/no), enrolment source (in-person/mail/telephone interview), BMI and common chronic diseases at the baseline interview (hypertension, diabetes, heart attack, high cholesterol, stroke, chronic obstructive pulmonary disease, depression and cancer) and 2003 Rural-Urban Continuum codes. The ORs can be interpreted as the effects of predictive variables on the odds of being higher versus lower categories.

†Shown in the parentheses are the values at the first (Q1) and third (Q3) quartile.

‡The ORs (95% CIs) shown for continuous predictive variables were IQR effects.

BMI, body mass index; HEI, Healthy Eating Index; SCCS, Southern Community Cohort Study.

stress were analysed in separate models because they were highly correlated (correlation=0.67, not shown in the table). All of the associations were attenuated. Only religious service attendance >1/week (HR 0.90, 95% CI 0.84

to 0.95, $p<0.001$), depression score (HR 1.03, 95% CI 1.00 to 1.05, $p=0.028$) and social support (HR 0.97, 95% CI 0.94 to 1.00, $p=0.023$) were significantly associated with the all-cause mortality.

Table 2 The effects* of religious involvement, emotional well-being and social support on all-cause mortality

	All participants (14325 deaths)					
	Model 1†		Model 2‡		Model 3§	
	HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
Religious service attendance						
Never	Reference		Reference		Reference	
<1/week	0.97 (0.92 to 1.02)	0.172	1.02 (0.97 to 1.07)	0.426	1.03 (0.98 to 1.09)	0.258
1/week	0.89 (0.85 to 0.95)	<0.001	1.00 (0.95 to 1.06)	0.921	1.02 (0.96 to 1.08)	0.462
>1/week	0.76 (0.72 to 0.81)	<0.001	0.90 (0.84 to 0.95)	<0.001	0.92 (0.86 to 0.98)	0.007
Spirituality						
Not at all	Reference		Reference		Reference	
Slightly	1.06 (0.94 to 1.19)	0.337	1.07 (0.95 to 1.21)	0.246	1.04 (0.91 to 1.18)	0.587
Fairly	0.95 (0.84 to 1.06)	0.324	0.98 (0.87 to 1.09)	0.686	0.95 (0.83 to 1.08)	0.420
Very	0.89 (0.80 to 1.00)	0.044	0.97 (0.87 to 1.09)	0.630	0.98 (0.86 to 1.12)	0.762
Importance of religion						
Not very much	Reference		Reference		Reference	
Somewhat	1.04 (0.94 to 1.15)	0.402	1.06 (0.96 to 1.18)	0.235	1.08 (0.96 to 1.21)	0.18
Quite a bit	0.98 (0.90 to 1.08)	0.739	1.03 (0.93 to 1.14)	0.479	1.06 (0.95 to 1.18)	0.274
A great deal	0.87 (0.80 to 0.96)	0.003	0.96 (0.88 to 1.05)	0.402	1.00 (0.89 to 1.11)	0.942
Depression score	1.07 (1.05 to 1.10)	<0.001	1.03 (1.00 to 1.05)	0.028	1.02 (1.00 to 1.05)	0.078
Personal stress	1.03 (1.01 to 1.05)	0.004	1.00 (0.98 to 1.02)	0.989		
Social support	0.93 (0.91 to 0.96)	<0.001	0.97 (0.94 to 1.00)	0.023	0.97 (0.94 to 1.00)	0.078

*The HR (95% CI) for the effects were estimated using the mixed effects Cox model.

†The covariates included in model 1 were basic demographic and socioeconomic variables; they were age at enrolment, gender, race, marital status, education levels, household income, insurance coverage (yes/no), enrolment source (in-person/mail/telephone interview), body mass index, common chronic diseases at the baseline interview (comorbidity index, hypertension, diabetes, heart attack, high cholesterol, stroke, chronic obstructive pulmonary disease and cancer) and 2003 Rural-Urban Continuum codes. The Southern Community Cohort Study-derived deprivation index was treated as the random effect.

‡In addition to the covariates in model 1, model 2 was further adjusted for lifestyle factors (smoking status, number of alcohol drinks, physical activity and Healthy Eating Index), depression score or personal stress, and social support.

§In addition to the covariates in models 1 and 2, model 3 included all religion-related variables (religious service attendance, spirituality, perceived importance of religion) for mutual adjustment.

Table 3 The effects* of religious involvement, depression score and social support on cause-specific mortality in all SCCS participants

	Cancer (3509 deaths)		CVD (4473 deaths)		Other causes (5186 deaths)	
	HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
Religious service attendance						
Never	Reference		Reference		Reference	
<1/week	0.93 (0.84 to 1.03)	0.178	1.08 (0.98 to 1.18)	0.136	1.05 (0.96 to 1.14)	0.293
1/week	0.97 (0.87 to 1.09)	0.624	1.09 (0.98 to 1.21)	0.098	0.99 (0.90 to 1.10)	0.912
>1/week	0.85 (0.75 to 0.97)	0.014	0.95 (0.85 to 1.07)	0.400	0.91 (0.81 to 1.01)	0.075
Spirituality						
Not at all	Reference		Reference		Reference	
Slightly	0.89 (0.68 to 1.15)	0.365	1.27 (0.98 to 1.63)	0.067	0.92 (0.74 to 1.13)	0.423
Fairly	0.81 (0.63 to 1.04)	0.102	1.15 (0.89 to 1.49)	0.270	0.85 (0.69 to 1.04)	0.119
Very	0.87 (0.67 to 1.12)	0.266	1.15 (0.89 to 1.49)	0.281	0.90 (0.73 to 1.10)	0.304
Importance of religion						
Not very much	Reference		Reference		Reference	
Somewhat	1.05 (0.84 to 1.32)	0.644	1.14 (0.92 to 1.42)	0.229	1.14 (0.94 to 1.38)	0.186
Quite a bit	1.00 (0.80 to 1.24)	0.980	1.06 (0.87 to 1.30)	0.561	1.20 (0.99 to 1.46)	0.059
A great deal	0.94 (0.76 to 1.17)	0.608	0.96 (0.78 to 1.18)	0.720	1.14 (0.94 to 1.38)	0.173
Depression score	0.96 (0.91 to 1.02)	0.173	1.02 (0.97 to 1.06)	0.449	1.05 (1.01 to 1.09)	0.024
Social support	1.02 (0.96 to 1.08)	0.478	0.99 (0.93 to 1.04)	0.600	0.94 (0.89 to 0.99)	0.023

*The HR (95% CI) for the effects were estimated using the mixed effects Cox model. The covariates included in the model were the same as model 3 in table 2.

CVD, cardiovascular disease; SCCS, Southern Community Cohort Study.

In model 3, we further included all religion-related variables, religious service attendance, spirituality and personal importance of religion in the same model for mutual adjustment. Only the association for religious service attendance >1/week (HR 0.92, 95% CI 0.86 to 0.98, $p=0.007$) remains statistically significant, but was further attenuated. That is, relative to those who never attended, all-cause death was reduced by 8% for those who attended religious service attendance >1/week. Personal stress was not included in model 3 because it was not significant in model 2 and it was highly correlated with the depression score.

Table 3 showed the effects of religious involvement, depression score and social support on cause-specific mortality using model 3. Relative to those who never attended, cancer death was reduced by 15% for those who attended religious service attendance >1/week (HR 0.85, 95% CI 0.75 to 0.97, $p=0.014$). Depression score and social support were only significantly associated with other cause mortality.

We further analysed the heterogeneity of the associations of religious service attendance with all-cause mortality and cancer mortality across socioeconomic and lifestyle factors (table 4). We observed that the association for religious service attendance >1/week was more evident among those with higher education levels (p for association heterogeneity=0.025) and among former smokers or those who never smoked (p for association

heterogeneity=0.004). This pattern was also observed for higher household income, less alcohol drinking, more physical activity and higher diet quality, although less evident. We created a combined score using the predicted values from a logistic regression model with the death of all causes as the dependent variable and these six socioeconomic and lifestyle factors as the independent variables. Those with more beneficial socioeconomic and lifestyle factors would have higher combined score. We found that the association of religious service attendance >1/week with all-cause mortality was more evident among persons with higher combined score (p for association heterogeneity=0.073).

For cancer mortality, we also observed that the inverse association (HR 0.74, 95% CI 0.59 to 0.92, $p=0.008$, not shown in the table) for religious service attendance >1/week was more evident among those with higher education levels (p for association heterogeneity=0.065), but this pattern was not observed for other socioeconomic and lifestyle factors.

DISCUSSION

In this large prospective long-term cohort of primary low-income black and white participants, we observed that religious service attendance was significantly related to socioeconomic and lifestyle factors, in agreement with previous reports.^{6 14 38} We observed that religious service

Table 4 The effects* of religious service attendance on all-cause mortality in all SCCS participants, stratified by socioeconomic and lifestyle factors

	Religious service attendance					
	<1/week		1/week		>1/week	
	HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
Education level						
<High school	1.11 (1.02 to 1.21)	0.018	1.07 (0.98 to 1.18)	0.144	0.96 (0.86 to 1.07)	0.437
High school	1.05 (0.95 to 1.15)	0.352	1.06 (0.96 to 1.18)	0.267	0.91 (0.81 to 1.02)	0.100
>High school	0.91 (0.82 to 1.01)	0.078	0.88 (0.79 to 0.99)	0.031	0.84 (0.75 to 0.95)	0.004
p for association heterogeneity†= 0.025						
Smoking status						
Current smoker	1.05 (0.98 to 1.12)	0.120	1.05 (0.97 to 1.13)	0.255	1.00 (0.92 to 1.10)	0.917
Former smoker	1.04 (0.93 to 1.16)	0.473	1.03 (0.91 to 1.15)	0.673	0.86 (0.75 to 0.97)	0.017
Never smoked	0.92 (0.81 to 1.04)	0.182	0.92 (0.81 to 1.05)	0.230	0.82 (0.72 to 0.94)	0.005
p for association heterogeneity=0.004						
Combined score‡						
Low	1.05 (0.97 to 1.14)	0.174	1.07 (0.98 to 1.17)	0.142	0.99 (0.89 to 1.09)	0.805
Middle	0.99 (0.91 to 1.07)	0.736	1.01 (0.93 to 1.09)	0.860	0.89 (0.81 to 0.97)	0.006
High	0.95 (0.78 to 1.17)	0.639	0.81 (0.65 to 1.00)	0.045	0.75 (0.60 to 0.94)	0.012
p for association heterogeneity=0.073						

*The HR (95% CI) for the effects were estimated using the mixed effects Cox model. The covariates included in the model were the same as model 3 in table 2.

†The p values for association heterogeneity were derived using the log-likelihood ratio test by comparing the mixed effects Cox models with and without including the interaction terms.

‡The combined score was calculated as the predicted values from the logistic regression model with the death from all causes as the dependent variable and the socioeconomic and lifestyle factors (age at enrolment, gender, education levels, household income, smoking status, alcohol drinking, physical activity and Healthy Eating Index) as the independent variables.

attendance >1/week was significantly associated with lower overall and cancer mortality. Depression score was significantly associated with other cause mortality. Spirituality, personal importance of religion and social support did not show significant associations with mortality in multivariate analyses.

Behavioural, emotional and social factors, as measured in the SCCS, behaved like mediator of the relationship between religious involvement and mortality.³⁹ They are associated with measures of religious involvement, and when controlled for in a multivariate model, they attenuate the strength of association between the religious involvement measures and mortality, as shown with model 2 in table 2. After adjustment for possible mediators, only the effect of religious service attendance remained significant but substantially attenuated, which was slightly further attenuated with adjustment for other religious involvement, depression score and social support (model 3). These findings suggested that the effect of religious service attendance may involve pathways of influence that are not accounted for by the mediational and demographic variables in our models.

Previous studies and systematic reviews concluded that greater religious involvement predicted greater longevity, and indicated about one-third average increase

in survival.¹⁻¹² Recently, Li *et al* reported a 33% lower mortality risk for those who attended religious services >1/week compared with women who never attended religious services among US nurses, who were better educated than the general population. In our study, we found 8% lower all-cause mortality and 15% lower cancer-specific mortality when comparing religious services attendance >1/week with non-religious services attendance. The effect sizes in our study were much smaller than the previous reports, which could be partially explained by the following: first, in the current analysis, we have extensively adjusted for multiple socioeconomic and lifestyle factors, and for other religious involvement, depression score and social support as well. These adjustments corrected for overestimates of some previous reports; and second, the current study participants were enrolled from underserved populations in the Southeastern USA with low household income. As demonstrated in table 4, socioeconomic and lifestyle factors, in addition to their confounding effects, could modify the effect of religious service attendance on mortality, with this effect being weaker among those who had low socioeconomic status and less healthy lifestyles. Extreme poverty and deprivation may reduce the salutatory effect of church attendance and other aspects of religious involvement on health and longevity.

Unmeasured factors could at least partially account for the strong inverse association of religious service attendance and mortality reported in some previous studies. Our study showed that participants who attended religious services >1/week were more likely to have higher socioeconomic status and healthier lifestyles. It is likely that these people would be more health conscious and have better access to healthcare,^{26 40–42} and therefore would have lower mortality regardless of their religious involvement.

Empirical studies show that people tend to over-report their religious service attendance. Because of the prospective study design, we expect this over-reporting would be non-differential, which will tend to attenuate study results. On the other hand, we might have underestimated the effect of religious service attendance by adjustment for lifestyle factors as these variables may be mediators of the relationship. A number of studies suggested that religious participants may have healthier lifestyle. They were more likely to quit smoking,^{43 44} less likely to abuse alcohol,^{44–46} have better diet⁴⁴ and engaged in more physical activities.^{44 47} Therefore, these factors may mediate the association between religious service attendance and mortality, rather than confound the association.

Our study has several limitations. First, most of the SCCS participants were recruited at CHCs,²³ which were not representative of the general US southern population. Therefore, the results of this study should not be generalised to the general population. Next, we did not collect the data on religious coping, religious affiliation and other aspects of religion and spiritual, which might affect mortality differently. Finally, our assessment of religion involvement was limited by data measure at one point at the baseline; the study findings are subject to reverse causation issues. To ease the concern of reverse causation, we also conducted the Cox regression analyses with exclusion of deaths occurred within 2 years after the baseline survey and found the results remained virtually unchanged.

In conclusion, religious services attendance >1/week was associated with lower all-cause mortality, and particularly with lower cancer mortality in this large prospective cohort study of underserved populations in the South-eastern USA. The strength of the association with all-cause mortality was reduced for people with lower socioeconomic status. The finding of this study may be of interest and importance to religious communities and healthcare providers. Given the importance of religion and participation in the church for the underserved population in the Southeastern USA and accessibility of religion to most members of the community, religious service attendance appears to be a valuable resource for promoting health among this disadvantaged population.

Contributors Contributors WW, WJB and WZ conceived the original study idea. WJB and WZ organised the data collection. WW conducted data analyses with input from DS and SWA. WW wrote the first draft and all coauthors (WW, DS, SWA, WJB and WZ) contributed to the revision of the draft and approved the final version for submission.

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