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THE RELATIONSHIP BETWEEN ATTENDANCE AT RELIGIOUS SERVICES AND CARDIOVASCULAR INFLAMMATORY MARKERS*†

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ABSTRACT

Objective: Previous studies have shown an association between attendance at religious services and health, particularly cardiovascular morbidity and mortality. Little research has focused on religious attendance and physiological markers of cardiovascular risk. The purpose of this study was to explore the relationship between religious attendance and inflammatory markers of cardiovascular risk. *Method:* Nationally representative sample of non-institutionalized United States adults aged 40 and over derived from the National Health and Nutrition Examination Survey III 1988-1994 (n = 10,059). The main outcome measures were the inflammatory system markers C-reactive protein, fibrinogen, and white blood cell count. *Results:* 40.8 percent of the population attended religious services 40 or more times in the previous year while 22.4 percent attended services less than 40 times and 36.8 percent attended no religious services at all. Non-attenders of religious services were more likely than attenders to have elevated white blood cell counts (p = .001), highly elevated C-reactive protein (p = .02), and elevated fibronogen (p = .05). After adjusting for demographic variables, health status,

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and BMI, the association between religious attendance and cardiovascular markers remained. Once current smoking was added to the model the independent effect of religious attendance dropped below conventional confidence limits. *Conclusions:* These findings suggest that people who have attended religious services in the previous year are less likely to have elevated levels of certain inflammatory markers, however, current smoking has significant shared variance with religious attendance.

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Key Words: religion, inflammation, cardiovascular disease

INTRODUCTION

Religious beliefs and behaviors, especially religious service attendance, have been associated with lower mortality and better physical health, including lower rates of stroke, myocardial infarction and cardiovascular death [1-5]. A recent 5-year long longitudinal study in northern California found that persons who attended religious services had lower mortality than those who did not, even after controlling for demographics, health status, physical functioning, health habits, social functioning and support, and psychological state [6]. Strawbridge and colleagues [7] looked at the association between religious attendance and mortality over 28 years in a cohort of over 5000 people and found that frequent attenders of religious services had lower mortality than infrequent attenders. Levin [8] and others propose biologic as well as psychological mechanisms to explain the association of religious commitment and better health outcomes. However, the pathophysiologic mechanisms of these associations are not well understood, and more in depth research is not available. Illuminating the "black box" between religious commitment and health outcome is therefore an important priority for current research.

Recent evidence suggests that psychological factors including religiosity are associated with inflammatory and immune system markers and may act as mediators in their health effects [2, 9-12]. Berk et al. [11] found that levels of C-reactive protein were significantly higher in patients with a depressive disorder compared to controls [11]. Fibrinogen has been investigated as a mediator in the body's response to psychosocial stress and found to be independently associated with personal/economic problems [12]. Koenig and colleagues have investigated the relationship between attendance at religious services and interleukin-6 (IL-6), an inflammatory cytokine and immune system regulator, and found that religious attendance was inversely related to high IL-6 levels [2]. This evidence, combined with recent findings that higher religious commitment has been linked to a 20 percent lower risk of death from coronary heart disease [4], leads to the consideration that inflammatory proteins may act as mediators of religion's association with cardiovascular disease.

After reviewing recent research on inflammatory markers as predictors of increased cardiovascular risk [13, 14] and on the link between religious commitment and cardiovascular health [4, 15], we sought to further investigate the relationships between frequency of religious attendance and inflammatory markers associated with cardiovascular disease.

METHODS

The sample was derived from the National Health and Nutrition Examination Survey III (NHANES III), 1988-1994, a cross-sectional study of a nationally representative sample of noninstitutionalized U.S. residents. We limited the participants in this analysis to adult patients ($\geq$ 40 years of age) excluding those currently on systemic corticosteroid medication, anti-neoplastic agents, and non-steroidal anti-inflammatory agents because of confounding that might occur due to their anti-inflammatory effects. Everyone in the study sample had blood drawn for CV markers.

Dependent Variables—Inflammatory Markers

C-reactive protein, fibrinogen, and white blood cell count were measured as part of the NHANES III physical and laboratory examination. Standard phlebotomy techniques were used to obtain specimens. Serum specimens were frozen to –20 degrees Centigrade until used for laboratory analysis. C-reactive protein was analyzed using a fully automated Behring Nephelometer Analyzer System (Behring Diagnostics Inc., Somerville, New Jersey). Fibrinogen was analyzed using the Coagamate XC Plus automated coagulation analyzer (Organon Teknika, Durham, North Carolina). White blood cell count was included as part of the complete blood count performed using the Coulter Counter Model S-PLUS JR automated hematology analyzer. Further details about the specific methods used in the laboratory procedures of the NHANES III are available elsewhere [16].

Elevated levels of inflammatory markers were defined using cutoff points based on previous studies of cardiovascular disease. Our purpose was to use threshold levels that have clinical meaning as predictors of cardiovascular disease and cardiovascular events. In the study by Abdelmouttaleb and colleagues [13], mean C-reactive protein levels were 1.16 (mg/dl) in participants with unstable angina, 0.71 in participants with a history of coronary disease, and 0.23 in healthy controls. Thus, in the current study, values above 0.3 mg/dl were considered elevated and above 1.0 mg/dl were considered highly elevated. The > 1.0 mg/dl level for C-reactive protein corresponds to the greater than 90th percentile distribution for the test.

Fibrinogen level above the 90th percentile of distribution was found in a previous study to be associated with a twofold increase in myocardial infarction risk, thus the 90th percentile ($\geq$ 424 mg/dl) was used in this study to delineate an elevated level [17].

The upper limit of the reference range for white blood cell count in the NHANES III was 11,300/mm3 in adults; a level above 12,000/mm3 (approximately 97th percentile of the distribution) was used in this study to indicate "elevation" to eliminate ambiguity about the meaning of "high normal" values.

Independent Variable—Religious Attendance

Frequency of attendance at religious services per year was measured by self-report in answer to the following question: "How often do you attend church or religious services? (per year)" The answer was given as a single number indicating times per year.

Control Variables

Standard demographic and socioeconomic indicators (age, race, sex, education, and total household income in last 12 months) were included as control variables. C-reactive protein levels are known to vary by age, gender, and race [18]. In an effort to determine the independent relationship between frequency of attendance at religious services and each inflammatory marker, additional variables were included that might influence the levels of the inflammation indicators or attendance at religious services. These included self-reported health status ("In general is your health excellent, very good, good, fair, poor?") number of chronic diseases, smoking and BMI [19-21]. Chronic diseases were determined by self-report ("Has a doctor ever told you that you had . . . ?") and included the following conditions: arthritis, heart failure, stroke, asthma, chronic bronchitis, emphysema, hay fever, cataracts, goiter, other thyroid disease, lupus, gout, skin cancer, and other cancer. Smoking was coded as a yes or no to current smoking ("Do you currently smoke cigarettes?"). BMI was calculated in the NHANES III using the weight and height data in the examination file.

Analysis Plan

Weighting variables were used in SUDAAN to account for the complex sampling design of the NHANES III. We initially performed descriptive statistics, then computed *t*-tests between mean frequency of religious attendance and each inflammatory marker. Initial unadjusted analysis revealed that religious attendance was associated with C-reactive protein as a continuous and as a categorical variable. Consequently, we examined religious attendance against the other outcome variables both as a continuous and as a dichotomous variable.

For four categorical outcomes (white blood cell count $\geq$ 12,000, C-reactive protein $\geq$ 0.3 mg/dl and $\geq$ 1.0 mg/dl, and fibrinogen $\geq$ 424 mg/dl), three-step logistic regression was used to examine the association with frequency of religious attendance. First, religious attendance was examined alone in the model (0 times of religious attendance was defined as "non-attender" and $\geq$ 1 times was defined as "attender"). Second, the demographic covariates age, race, gender, education, and income were added to the model to control for their effects. Medical covariates of self-reported health status, number of chronic diseases, smoking, and BMI were also added to the model at this stage. Third, smoking was removed from the model to evaluate its effect separately. Standardized betas, *p*-values, odds ratios, and 95 percent confidence intervals were obtained from the logistic regression output. Statistical significance was defined as $p \leq 0.05$.

RESULTS

There were 33,994 people who took part in the NHANES III 1988-1994; 10,059 respondents age 40 and over were included in this analysis. The demographic and medical characteristics of the participants are described in Table 1 according to whether they attended religious services in the previous year. In terms of frequency of attendance at religious services in the past year, 63.2 percent attended 1 or more times and 36.8 percent attended no religious services.

The mean number of religious services attended per year was significantly lower in people with elevated white blood cell count ($p < .001$), highly elevated C-reactive protein ($p < .001$), and any elevated C-reactive protein ($p = .02$), but was not significantly lower in participants with elevated fibrinogen ($p = .26$).

Table 2 illustrates the differences in elevation of inflammatory markers according to attendance as a dichotomous variable. The percent of participants with elevated white blood cell count, highly elevated C-reactive protein, and fibrinogen was lower among attenders than nonattenders of religious services, but not for modest elevations of C-reactive protein.

After controlling for demographic and medical covariates using logistic regression, the association between religious attendance and selected inflammatory markers is no longer present. The odds ratios for elevated levels of inflammatory markers among attenders of religious services are shown in Table 3, using non-attenders as the reference category. The results indicate non-significant differences between attenders and non-attenders in regard to the risk of elevated inflammatory markers. After removing smoking from the model, the odds ratios for elevated white blood count ($p = .01$) and highly elevated C-reactive protein ($p = .02$), were again significant, while any elevation of C-reactive protein and fibrinogen were not ($p = .15$, $p = .13$ respectively). Using religious attendance as a continuous variable in the regression analysis that included smoking did not alter the significance levels to below our predetermined threshold (C-reactive protein, $p = .06$; white blood count, $p = .07$).

Table 1. Population Characteristics by Attendance of Religious Services[a]

	Attenders (%)	Non-attenders (%)	*p* value
Gender			
Male	44.3	54.0	< .001
Female	56.7	46.0	
Age			
40-64	69.6	69.5	.94
65 and above	30.4	30.5	
Race			
Non-Hispanic White	78.4	85.8	< .001
Non-Hispanic American African	11.0	6.3	
Hispanic	4.1	2.4	
Other	6.5	5.5	
Education			
Less than high school	27.4	34.8	< .001
High school degree	31.6	33.5	
Some college	17.8	14.4	
College degree	11.8	8.4	
Above college	11.4	8.9	
Income (annual)			
0-15,000	26.8	31.2	.01
15-30,000	24.4	26.0	
30-50,000	23.7	21.2	
Over 50,000	25.1	21.6	
Health status			
Poor	3.5	6.5	< .001
Fair	14.2	17.2	
Good	32.8	34.5	
Very good	28.5	26.2	
Excellent	21.0	15.6	
Number of chronic diseases			
None	49.8	48.7	.09
1	28.1	26.5	
2 or more	22.1	24.8	
Current smoking			
Yes	37.0	46.0	< .001
No	63.0	54.0	
BMI			
Mean	27.1	26.4	.73

[a]Weighted in SUDAAN.

Table 2. Elevated Inflammatory Markers by Religious Attendance

	Attenders (%)	Non-attenders (%)	*p* value
White blood cell count			
Elevated (≥ 12,000/mm^3)	2.08	4.05	.001
C-reactive protein			
Highly elevated (≥ 1.0 mg/dl)	7.90	10.35	0.02
Elevated (≥ 0.3 mg/dl)	32.26	35.26	0.11
Fibrinogen			
Elevated (≥ 424 mg/dl)	6.53	8.20	0.05

Table 3. Unadjusted and Adjusted Relationships between Religious Service Attendance and Markers of Inflammation

	Unadjusted OR (95% CI)	Adjusted[a] OR (95% CI)
White blood cell count (≥ 12,000/mm^3)	0.53 (0.37, 0.75)	0.78 (0.56, 1.07)
C-reactive protein (≥ 1.0 mg/dl)	0.74 (0.58, 0.94)	0.83 (0.66, 1.04)
C-reactive protein (≥ 0.3 mg/dl)	0.87 (0.74, 1.03)	0.93 (0.78, 1.11)
Fibrinogen (≥ 424 mg/dl)	0.78 (0.60, 1.01)	0.86 (0.66, 1.13)

(Reference category = no attendance in past year)
[a]Controlling for age, gender, race-ethnicity, education, income, self-reported health status, number of chronic diseases, smoking, and BMI. OR = odds ratio, CI = confidence interval.

DISCUSSION

The findings of this study indicate a significant unadjusted relationship between attendance at religious services and levels of selected inflammatory markers. However, these relationships did not remain significant after adjusting for potential confounding variables. When smoking was removed from the model, two of the four relationships tested were again significant, indicating a co-linear relationship between smoking and attendance at religious services.

Several factors may explain the trends seen in the association of religious attendance with some inflammatory markers but not others. First, it is possible that the selected inflammatory markers are susceptible to changes in psychological/spiritual stress as well as levels of inflammation from smoking and other factors. Second, the inflammatory affects of smoking may affect some inflammatory markers more than others. Finally, the percentile levels to use as a cutoff point for categorizing "elevated" inflammatory markers are still being developed and are based on those used in previous studies rather than physiologic rationale.

C-reactive protein, fibrinogen, and white blood cells were chosen for evaluation in the current study because of their prominent roles in the inflammatory response and because they have been related to an increased risk of cardiovascular events [19, 20, 22, 23]. Epidemiologic data have documented the association between elevation of C-reactive protein levels and cardiovascular risk in people with and without a history of heart disease [14, 24-27]. Abdelmouttaleb [13] has found elevated C-reactive protein levels among patients with unstable angina compared to normal healthy controls. Elevated white blood cell count and fibrinogen have been reported as independent risk factors for ischemic heart disease [19, 28]. The inflammatory markers used in this study are clearly integral to the prominent role of inflammation in cardiovascular risk.

The present study adds new information to our understanding of cardiovascular disease risk and has several implications for practice and ongoing research. The finding that the association between religious attendance and inflammatory markers is mediated by smoking strengthens the hypothesis that smoking increases cardiovascular risk by causing inflammation. If the risk of CV disease attributable to smoking is due to inflammation, then the risk may be modifiable by anti-inflammatory treatment in those unable to quit smoking.

A further implication of the current study is that there is much more to learn about religious commitment and the inflammatory response. The finding of an association between religious attendance and C-reactive protein and its confounding by smoking in a study not designed for this purpose implies that further research using more refined and sensitive measures of intrinsic religious commitment may uncover more evidence of physiologic change.

Limitations of this study include the operationalization of the religious attendance variable. The only question available in the data to assess religious commitment was the single question about frequency of attendance at religious services. Although frequency of attendance is often used as an indicator of religious commitment, there are obvious differences in churches and religions and what is entailed in attending these varied services [29, 30]. Consequently, the finding of a trend in inflammatory markers in spite of the lack of precision of this variable carries even greater implications. Second, the fact that religious attendance and some control variables were self-reported may have led to misclassification bias with under or over reporting. However, the use of standard validated measures of inflammation in the NHANES III does provide added confidence in the estimates. Third, although a trend was found based on religious attendance, delineating whether this effect is an artifact of general social activity, a marker of physical health status, or a result of internal religious commitment is uncertain. The variables available in the NHANES III to measure physical health status, i.e., self-rated health and number of chronic diseases, may lack adequate sensitivity. People with higher levels of inflammatory measures may have been too ill to attend religious services. However, the NHANES III does not include institutionalized persons, thus participants had to be well enough to attend the NHANES examination for several days.

More research is clearly needed to investigate the concept that there is a chain of events that may link religious commitment to cardiovascular health outcomes by way of inflammatory mediators. Future exploration should focus on determining whether there is an independent effect of intrinsic religious commitment separate from social support, health status, and health habits such as smoking. Future studies should use more complete measures of religious and spiritual factors and include other inflammatory mediators.

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