C-Reactive Protein, Diabetes, and Attendance at Religious Services

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OBJECTIVE — Previous studies have shown an association between attendance at religious services and health, particularly cardiovascular morbidity and mortality. People with diabetes have higher risk of cardiovascular mortality and higher C-reactive protein (CRP) levels than people without diabetes. The purpose of this study was to explore the relationship between religious attendance and CRP in people with diabetes.

RESEARCH DESIGN AND METHODS — This study used cross-sectional survey and examination of a nationally representative sample of noninstitutionalized U.S. adults aged ≥40 years, derived from the National Health and Nutrition Examination Survey III 1988–1994 (n = 10,059). There were 556 people with diabetes. The primary outcome measure was the presence of elevated CRP.

RESULTS — There were no differences between people with diabetes compared with people without diabetes in the percentage of those who attended religious services (62.29 vs. 62.0%, $P = 0.36$). Religious service nonattenders with diabetes were more likely than attenders to have an elevated CRP (odds ratio [OR] 2.17 [95% CI 1.15–4.09]). In people without diabetes, the association between attendance and CRP was not significant ($P > 0.05$). Among people with diabetes, after adjusting for demographic variables, health status, smoking, social support, mobility, and BMI, the association between religious attendance and CRP remained significant for respondents with diabetes (1.90 [1.03–3.51]).

CONCLUSIONS — These findings revealed that people with diabetes who have not attended religious services in the previous year are more likely to have elevated levels of CRP. Further research should be conducted to evaluate this association to improve our understanding of the psychological and religious factors that influence diabetes.

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The heightened interest in exploring the interaction between religion, spirituality, and health-related outcomes has focused on the field of psychoneuroimmunology (PNI). Much of the work in this area concentrates on the influence of stress on physiological systems and the impact of stress on the immune system. More recently, PNI research has focused on the attenuating effects of spiritual practices (such as meditation, prayer, and attendance at religious services) on various biologic and inflammatory markers (1). In addition, there is growing evidence of an association between acute inflammatory markers, such as C-reactive protein (CRP), and the risk of acute coronary syndromes and other forms of cardiovascular disease (2,3). Furthermore, attendance at religious services has been linked epidemiologically to improved morbidity and mortality from cardiovascular causes (4,5). Whether the association between spiritual practices, such as religious attendance, and improved cardiovascular outcome is mediated by biological proteins involved in the inflammatory and immune system is unknown.

Recent evidence suggests that psychological, social, and religious factors are associated with changes in levels of inflammatory markers (6–8). Berk et al. (7) found that levels of CRP were significantly higher in people with a depressive disorder than in control subjects. Koenig et al. (1) have investigated the relationship between attendance at religious services and interleukin-6 (IL-6), an inflammatory protein related to the production of CRP, and found that religious attendance was inversely related to high IL-6 levels. Other evidence suggests in bivariate analysis that attenders of religious services in the general population are less likely to have elevated CRP (9). In adjusted analyses, the association was no longer significant. However, because patients with diabetes tend to have elevated CRP (10), the impact of a mediating variable such as religious attendance would be more likely to be evident than in the general population that does not have elevated CRP.

The clinical relevance of the association between psychosocial/religious factors and physiological markers is supported by recent evidence of the role of inflammatory biomarkers like CRP with cardiovascular disease and acute coronary syndromes. Recent data have demonstrated that elevated CRP is an independent risk factor for myocardial infarction (2,3). CRP is elevated in people during acute coronary syndromes and in populations with increased cardiovascular risk (2,11). CRP is more elevated in people with diabetes than in people without diabetes and may contribute to their increased risk of cardiovascular complications (10,12). One recent study has implicated that elevated CRP levels are associated with an increased risk of developing diabetes (13). Another study reported that people with newly diagnosed diabetes, previously diagnosed diabetes, and impaired fasting glucose are more likely to have elevated CRP than people without diabetes, even after controlling

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Abbreviations: CRP, C-reactive protein; IL-6, interleukin-6; NHANES III, National Health and Nutrition Examination Survey III; OR, odds ratio; PNI, psychoneuroimmunology.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

for demographic factors and BMI (10). Other researchers have found CRP to be positively associated with diabetes, peripheral arterial disease, hypertriglyceridemia, and uncontrolled diabetes (14).

Because CRP is emerging as an important independent risk factor for the development of cardiovascular disease, learning more about psychosocial and religious factors that may mediate CRP levels is becoming increasingly important. In a population at high risk of cardiovascular disease, such as people with diabetes, psychosocial and religious practice influences on inflammatory mediators may be more pronounced. Combined with recent findings that higher religious commitment and religious service attendance has been linked to a lower risk of death from coronary heart disease (4,15,16), the hypothesis that attendance at religious services may play a role in modulating CRP level bears investigation. We sought to further investigate the relationship between attendance at religious services and CRP in people with diabetes.

RESEARCH DESIGN AND 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 civilian U.S. residents; the current study is based on an analysis of participants ≥40 years of age.

Respondents were stratified by their answer to the question, "Has your doctor ever told you that you have diabetes?" We excluded subjects with gestational diabetes and those currently on systemic corticosteroid medication, antineoplastic agents, and nonsteroidal anti-inflammatory agents because of confounding that might occur due to their anti-inflammatory effects. A total of 96% of the respondents had a usable sample of serum for analysis for CRP.

Dependent variables: inflammatory markers

CRP was 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°C until used for laboratory analysis. CRP was analyzed using a fully automated Behring Nephelometer Analyzer System (Behring Diagnostics, Somerville, NJ). Further details about the specific methods used in the laboratory procedures of the NHANES III are available elsewhere (17).

An elevated level of CRP was 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 et al. (11), mean CRP levels were 1.16 mg/dl in participants with unstable angina, 0.71 mg/dl in participants with a history of coronary disease, and 0.23 mg/dl in healthy control subjects. In addition, in the study by Ford (10), values in excess of 0.30 mg/dl were associated with increased cardiovascular risk and a BMI ≥ 30 kg/m^2. Kervinen et al. (3) used a similar cutoff point of 0.27 mg/dl to construct a model for relative risk of myocardial infarction. Thus, after considering these analyses, values >0.30 mg/dl were considered elevated.

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 variable was dichotomized to attendance "one or more times" per year (attender) or "no attendance" (nonattender) for logistic regression analyses.

Control variables

Standard demographic indicators (age, race, and sex) were included as control variables. CRP levels are known to increase with increasing age, female sex, and minority race (18). In an effort to determine the independent relationship between attendance at religious services and CRP, additional variables were included that are known to influence the level of CRP. These included smoking (19) and BMI (10,19). Smoking was coded as a "Yes" or "No" to a question about current smoking ("Do you currently smoke cigarettes?"). BMI was calculated in the NHANES III using the weight and height data in the examination file. We also included variables that would be expected to influence a person's ability to attend religious services, including self-reported health status ("In general is your health excellent, very good, good, fair, or poor?"), mobility, and social support. Self-reported mobility was determined by using a categorical question asking whether the respondent had difficulty in walking one-quarter of a mile. The answers could range from "No difficulty" to "Unable to do." A social support variable was created by the merging of several variables that asked how many contacts with friends or relatives the respondent had within one year. These included phone conversations, meeting with friends or family, and social club attendance.

Analysis plan

Analyses were limited to respondents aged ≥40 years who had a CRP level available. We initially performed descriptive statistics using *t* tests and χ^2, comparing respondents with diabetes to those without diabetes, stratified by attendance at religious services. Then, odds ratios (ORs) were computed to determine the odds of having an elevated CRP (>0.30 mg/dl) based on religious attendance as a dichotomous variable (attender versus nonattender). Then, logistic regression models were run to predict the odds of having an elevated CRP level >0.3 mg/dl. The main independent variable was attendance at religious services. Models were run on both diabetic and nondiabetic populations. In the adjusted models, demographic variables of age, race, and sex were used as controls. Also, several other variables that could affect CRP levels or religious attendance were included. These variables included BMI, smoking status, self-reported health status, self-reported mobility, and self-reported social contacts. Standardized β's, ORs, *P* values, and 95% CIs were obtained from the logistic regression output. SUDAAN was used for all analyses (except descriptive statistics, for which SAS [SAS, Cary, NC] was used) to obtain proper population estimates due to the complex sampling design of the NHANES III (20). Statistical significance was defined as $P \leq 0.05$.

RESULTS

— There were 10,059 people aged ≥40 years who took part in the NHANES III 1988–1994; 556 people with diabetes and 9,067 without diabetes had CRP levels available and were included in this analysis. The demographic and general health characteristics of the participants are described in Table 1 according to whether they attended reli-

Table 1—*Demographics of the study population of people with diabetes according to attendance at religious services*

	Attenders	Nonattenders	*P**
Age (years)	64.4 ± 12.0	68.1 ± 12.6	<0.001
Sex			
Male	42.1	53.8	<0.001
Female	57.9	46.2	
Race			
White	40	58.7	<0.001
Black	28.7	15.5	
Mexican-American	23.4	21.8	
Other	2.3	2.4	
Health Status			
Excellent	3.1	3.3	<0.001
Very good	11.7	10.9	
Good	33.6	30.8	
Fair	38.8	32.2	
Poor	12.8	22.8	
Smoking			
Nonsmoker	48.1	37.2	<0.001
Ex-smoker	38.7	41.6	
Smoker	13.2	21.2	
BMI (index)	29.1 ± 5.8	29.3 ± 3.6	0.36

Data are means ± SD or %. *Attenders vs. nonattenders.

gious services in the previous year. Among people with diabetes, 62.2% had attended religious services in the previous year, whereas 37.8% had not attended any services. There were no differences in the percentage who attended religious services between people with diabetes compared with people without diabetes (62.2 vs. 62.0%, $P = 0.36$)

Table 2 shows the percentage of people with elevated CRP according to religious attendance, stratified by whether they have diabetes. A significantly higher percentage of nonattenders have elevated CRP than attenders among people with diabetes ($P < 0.05$), but this does not hold for people without diabetes.

Among those with diabetes, nonattenders were more likely than attenders to have an elevated CRP (OR 2.17 [95% CI 1.15–4.09]). After adjusting for demographic variables, health status, mobility, social support, smoking, and BMI, nonattenders remained significantly more likely than attenders to have an elevated CRP (1.90 [1.03–3.51]) (Table 2). In people without diabetes, CRP did not vary significantly according to religious attendance in adjusted or unadjusted models (unadjusted OR 1.16 [0.86–1.57], adjusted OR 1.23 [0.87–1.75]).

Table 2—*Percentage of attenders versus nonattenders with elevated CRP, by diabetes status*

	Diabetes	No diabetes
Attenders	41.6	27.6
Nonattenders	60.6*	30.7

Data are %. *$P < 0.05$ compared with attenders.

Table 3—*Logistic regression models for prediction of elevated CRP*

	OR	95% CI
Diabetes		
Unadjusted		
Attender	1.00	1.00–1.00
Nonattender	2.17	1.15–4.09
Adjusted*		
Attender	1.00	1.00–1.00
Nonattender	1.90	1.03–3.51
No diabetes		
Unadjusted		
Attender	1.00	1.00–1.00
Nonattender	1.16	0.86–1.57
Adjusted*		
Attender	1.00	1.00–1.00
Nonattender	1.23	0.87–1.75

CONCLUSIONS — The findings of this study indicate a significant association between attendance at religious services and CRP among people with diabetes but not among people without diabetes. Both unadjusted and adjusted models demonstrated that among people with diabetes, religious service attendance status was a predictor of having an elevated CRP level >0.3 mg/dl. In each of these models, nonattendance at religious services showed a significantly increased chance of having an elevated CRP level. However, there was no association between religious attendance and elevated CRP in people without diabetes. The results are consistent with previous findings of an association between inflammatory proteins and other psychological factors (6–8). The results go beyond previous research linking religious attendance to morbidity to provide physiological evidence for a possible connection between religious attendance and markers of cardiovascular inflammation. Although the current study did not specifically explore the association between religious attendance and cardiovascular disease, the results support a theoretical model linking religious attendance, CRP, and cardiovascular disease in people with diabetes.

How religious attendance may be associated with systemic inflammation, CRP levels, and ultimately the development of cardiovascular disease in people with diabetes is not well understood. A variety of physical, psychological, spiritual, social, and lifestyle mechanisms have been proposed to explain the association of religious commitment and practice with physical health (21). These mechanisms include a reduction in stress or buffering of the stress response (21–23), enhancement of immune functioning (1), overcoming depression and anxiety (22), enhancement of social support and social networks (24,25), and reductions in unhealthy behaviors such as excessive use of alcohol, nicotine, and drugs (25). Religious practice, reflected in attendance at religious services, may operate through more than one physiological and psychological path to influence physical health outcomes.

Several alternative explanations for the findings in the current study warrant further discussion. First, attendance at religious services may influence cardiovascular risk in people with diabetes by way of the systemic inflammatory system (CRP). Such an association may be an independent effect or operate through

improved social support or other mechanisms (26,27). Previous studies have shown that religion-mediated social support is linked to lower morbidity but not specifically to cardiovascular inflammation in people with diabetes (28,29).

Another explanation that may explain the study results is that religious attendance is associated with lower rates of anxiety and stress and may reduce CRP levels through neurohormonal mechanisms (6,8,30). Elevated CRP levels are associated with blunted endothelial vasoreactivity and impaired vascular relaxation, an effect that has been linked to insulin resistance (13). A change in neuroendocrine mediators as a result of religious attendance may influence CRP levels at the endothelial level.

Another question raised by the results of the current study is why the association of religious attendance with CRP levels would be present among people with diabetes and not in people without diabetes. People with diabetes may be more susceptible to a modulating influence of religious attendance due to their higher CRP levels compared with the general population (10). Previous research that showed a lack of an association in the general adult population after adjustment for possible confounders was an impetus for the present study to focus on the relationship between religious attendance and CRP in a population with higher risk for elevated CRP (9). Demographic factors also may play a role because people with diabetes are older and in poorer health than people without diabetes and may exhibit different physiological or inflammatory responses to religious experiences. Furthermore, evidence is accumulating that inflammation, endothelial dysfunction, and insulin resistance are physiologically linked, thus providing a physiological basis for the relationship being more pronounced among people with diabetes (13).

The current study's finding of an association between CRP and religious attendance in people with diabetes adds to our understanding of the association between psychosocial/religious factors and markers of cardiovascular inflammation. By linking religious attendance and CRP, the current study's findings provide evidence for one possible physiological mechanism for lower cardiovascular mortality among attenders of religious services (4,5,15). Although the results of the current study are based on an analysis of adult people aged ≥40 years with diabetes, people in this population account for a substantial portion of people with cardiovascular disease. Furthermore, the findings strengthen the biopsychosocial model that psychosocial factors (e.g., attendance at religious services) may be linked physiologically to cardiovascular disease rather than solely through psychological mechanisms or the placebo effect. The results also strengthen the rationale for using the biopsychosocial model in clinical practice by including questions regarding attendance at religious services as part of the social history.

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 that make this single factor fall short of reflecting the large diversity of beliefs and worship experiences. Measures of personal spirituality and measures of intrinsic versus extrinsic religious commitment were not available in the NHANES III, making it impossible to further differentiate a specific mechanism for the association found in this study. Consequently, the finding of an association between CRP and religious attendance in people with diabetes despite the lack of precision of this variable may carry even greater implications.

One of the strengths of this study was the ability to control for social support and functional health measures. The association between religious attendance and CRP remained significant even after controlling for health status, mobility, and social support. This finding supports an independent association between religious attendance and CRP in people with diabetes. These results are consistent with previous research that found, in a 12-year follow-up study of the elderly, that disability has little effect on subsequent attendance at religious services (31). Another strength was the use of a large population from a nationally representative sample, the NHANES III. Use of such a large data set enabled us to control for several variables simultaneously, which a smaller sample size would not allow.

More research is clearly needed to investigate the concept that there is a chain of events that may link religious attendance to cardiovascular health outcomes by way of inflammatory mediators like CRP. Future exploration should include other inflammatory mediators as well as CRP and focus on determining whether there is an independent effect of intrinsic religious commitment separate from social support and functional health status. Future studies should also use more complete measures of religious commitment and spirituality. Such research will add to our understanding of the physiological mechanisms by which psychosocial factors like religious attendance may influence physical health, and it may provide insight for improving the management of diabetes.

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