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Response to Invited Commentary

VanderWeele et al. Respond to "Church Attendance and Mortality"

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We thank Dr. Krause for his remarks on the importance of social relationships in understanding the associations between religious service attendance and health (1). We welcome the opportunity to have a robust discussion of the challenges involved in measuring the impact of religious service attendance on mortality, and of strategies for advancing the field of religion/spirituality (R/S) research more generally.

Dr. Krause seeks in his commentary to add conceptual and theoretical depth to our findings by providing a discussion of the role of "social relationships that arise in religious institutions," thereby illustrating the kind of "in-depth conceptual analyses that are needed to move research in religious involvement and mortality to the next level" (1, p. 523). We agree with Dr. Krause that the dynamics underlying the association of church attendance with mortality are diverse and complex, and in fact we discuss the likely importance of social relationships in explaining this association in our paper (2). We were simply unable to explore these potential dimensions empirically due to the lack of measures on social relationships in religious settings in our data. Virtually no prospective cohort studies currently collect the kinds of detailed measurements needed to probe the complex dynamics underlying the relationship between service attendance and reduced risk of mortality. Investigators with our new project, the National Consortium on Psychosocial Stress, Spirituality, and Health (3), are now conducting a survey to collect additional data on measures of religiosity and spirituality in the Black Women's Health Study, as well as in a number of additional national cohorts, in order to better understand the complex ways in which R/S operates to affect human health. In fact, some of Dr. Krause's own measures intended to "unpack" service attendance are included in our current survey, upon his recommendation, and we look forward to sharing the results of these analyses in the future.

We further emphasize that religious and spiritual experience is as diverse as our national tapestry itself, and it is thus important that data sets used to investigate the complex relationship between service attendance and mortality, as well as between R/S and health more generally, be comprised of diverse populations. As with other sociocultural phenomena, we should anticipate that the complex ways in which R/S operates to affect health and health-care decision-making will not only differ according to individuals' religious/spiritual traditions or values but also by race/ethnicity, class, and various cultural commitments. We have thus designed our new consortium data set ($n > 5{,}000$) for the ability to draw conclusions regarding the relationship between R/S and health within African-American, Native American (Lakota), Latino (Puerto Rican), South Asian (Indian), and white American communities and to include participants from all socioeconomic strata. Participants also span a diversity of spiritual traditions, and we will assess persons practicing Native American spirituality, Hinduism, Islam, Judaism, Christianity, and other traditions, as well as those who identify as humanist, atheist, or agnostic. These results will complement Krause's Landmark Spirituality and Health Survey (http://landmarkspirituality.sph.umich.edu/), whose 3,000 participants are reported as being 60% white, 74% Christian, and 20% agnostic or atheist. We hope the diversity in our consortium will lead to a better understanding of the complex ways in which R/S shapes health trajectories and offer new leverage points for improving human health and reducing health disparities.

With respect to the methodological challenges of determining causality, the limitations of extant data are substantial. Among more than 20 national prospective cohort studies we recently surveyed (3), only about a dozen have ever measured attendance at religious services, and only a few have assessed church attendance at least 3 times, which (as discussed below) is what is most helpful in assessing causality and mechanisms. Krause himself points out the difficulties of having data on service attendance collected at only 1 time point: It becomes challenging to assess causal effects or to know what potential effects one is attempting to estimate. Krause also notes the predicament of deciding whether to control for baseline health: If one does not, baseline health may be a confounder; if one does, this may effectively block

some of the effect of past attendance. It is thus difficult to establish causation; assessing mechanisms empirically is yet more challenging still. In the Black Women's Health Study, we had access to data on religious service attendance at only 2 time points (2005 and 2013), but we had data on 3 additional R/S measures also collected in 2005. Given the lack of follow-up for the 2013 data (our analysis followed women through 2013, the last year for which data were available), we could only use the 2005 R/S measures. Our analysis contributed to current knowledge by assessing the prospective associations of service attendance with mortality while taking into account and also assessing 3 other potentially important R/S measures not previously included in most prior mortality analyses—namely prayer, self-identification as a religious or spiritual person, and the use of R/S to cope with stressful life events.

Using data from a different study, however—the Nurses' Health Study (NHS)—Li et al. (4) in fact attempted to address questions of temporality, causation, and mechanisms. While the NHS data had only 1 single R/S construct, namely service attendance, this was assessed repeatedly over time. It is such repeated measurements taken over time (of the service attendance exposure, along with health and potential confounders) that allow one to better assess questions of causation and mechanisms (5). With those data, Li et al. were able to control for both prior health and prior service attendance and to use prior values on numerous potentially confounding variables to evaluate associations of service attendance with subsequent health. The associations between religious service attendance and mortality, depression, and suicide were robust to this more rigorous control for confounding and feedback (4, 6, 7). Such an approach, by controlling for past attendance and health, allows one to address Krause's very important concern about feedback between religious participation and health (1, 5). Moreover, the availability of at least 3 repeated measurements also allows for the use of causal models, such as marginal structural models (5, 8), to examine the joint effects of religious service attendance over more extended periods of time, addressing one of Krause's other concerns about analyses of religious participation and health. Using such approaches, analyses of the NHS data indicate that while regular service attendance at a given time point is associated (controlling for confounders and past attendance) with an approximate 33% (95% confidence interval: 29, 38) reduction in mortality during follow-up, consistent service attendance over 2 time points at 4-year intervals is associated with a 50% (95% confidence interval: 46, 54) reduction in mortality (4).

Such repeated-measures data also allow one to better assess mechanisms (9). Ideally, when feedback between variables is operative, questions about mediation should be addressed using 4 waves of data, with the outcome at wave 4, the mediator(s) at wave 3, the exposure at wave 2, and potential confounders (potentially including baseline exposure, mediator, and outcome) at wave 1. Li et al. in fact used such an approach in the NHS analyses to obtain evidence that increased social support, decreased smoking, increased optimism, and decreased depression were all important mechanisms governing the association between service attendance and mortality (4). Using similar designs in other data, we are currently examining purpose in life and self-control as other possible mechanisms. We view these as important steps forward; and indeed, with the recent publication of these results (4), Krause's assertions that issues of temporality and feedback have not "been adequately addressed elsewhere" and that the findings have no "well-developed explanation" (1, p. 523) are arguably no longer applicable.

An intriguing question that motivated our analyses and that we returned to in our Discussion is whether various other dimensions of R/S are also important for mortality and other health outcomes. Our adjusted analyses for mortality suggested that of those other factors we examined—spiritual identity, religious coping, and prayer—the associations with all-cause mortality were weak in relation to service attendance (2). Only service attendance persisted as a strong predictor under multivariate adjustment. Such analyses are not conclusive, however. One may also be worried about negative confounding with prayer and religious coping, just as one worries about positive confounding with service attendance. Other dimensions of R/S may have a greater effect yet to be discovered. Dynamics may also vary with other outcomes (10).

Our analyses and the commentary by Krause again raise the question about what it is concerning religious service attendance that seems to matter. In the NHS analyses, changes in social support from religious service attendance seemed to explain only about a quarter of the association between attendance and health (4). In our present paper (2), we raised the question as to whether and to what extent one could disentangle, even conceptually, the social from the specifically religious components of the association of service attendance with health. Krause's point about attendance affecting the use of tobacco provides a poignant example. As Krause discusses (1), some religious people may believe their bodies to be temples of God, and this belief may be reinforced by their religious community; these beliefs, their communal reinforcement, and the resulting subsequent social norms may result in lower rates of smoking. In such a context, is such a reinforcing mechanism to avoid smoking "social" or "religious"? It seems difficult to answer in any way other than "both." Likewise, hypothesized mechanisms of a shared sense of (religious) meaning or purpose in life or a shared communal outlook shaped by faith, hope, love, or a commitment to social justice are often both religious and social. It is challenging to separate the two, and it is perhaps the intertwining of them that gives religious service attendance some of its power.

The search for other strong R/S predictors of health, beyond service attendance, remains relatively open. We believe advances in measurement and study design will be needed to address these questions, with a richer set of R/S variables measured in multiple waves. Such longitudinal study designs should become the norm in R/S research related to health (5, 11). We hope our current efforts in the National Consortium on Psychosocial Stress, Spirituality, and Health to incorporate numerous R/S measures and assess biological mechanisms through DNA methylation, telomere length, and other biomarker analyses will provide the kind of data that investigators will need in selecting R/S measures to add to their data collection efforts in the future. We

believe that adding a richer set of R/S measures to long-established prospective cohort studies, which have a wealth of demographic, environmental, and clinical data collected over decades from hundreds of thousands of participants, will form the research infrastructure needed to answer many of these long-standing questions regarding the mechanisms and pathways through which R/S operates to affect human health. Ensuring that such measures are integrated into diverse cohorts representing many different US racial/ethnic communities, cultures, and spiritual traditions may offer a new vantage point for understanding intractable disparities in the chronic disease burden in the United States and new opportunities for culturally tailored interventions and prevention efforts.

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