American Journal of
Preventive Medicine

RESEARCH ARTICLE

Volunteering and Subsequent Health and Well-Being in Older Adults: An Outcome-Wide Longitudinal Approach

Eric S. Kim, PhD,[1,2,3] Ashley V. Whillans, PhD,[4] Matthew T. Lee, PhD,[3] Ying Chen, ScD,[3,5] Tyler J. VanderWeele, PhD[3,5,6]

Introduction: Growing evidence documents strong associations between volunteering and favorable health and well-being outcomes. However, epidemiological studies have not evaluated whether changes in volunteering are associated with subsequent health and well-being outcomes.

Methods: Data were from 12,998 participants in the Health and Retirement Study—a large, diverse, prospective, and nationally representative cohort of U.S. adults aged >50 years. Using multiple logistic, linear, and generalized linear regression models, this study evaluated if changes in volunteering (between t_0, 2006/2008 and t_1, 2010/2012) were associated with 34 indicators of physical health, health behaviors, and psychosocial well-being (in t_2, 2014/2016). Models adjusted for sociodemographics, physical health, health behaviors, psychosocial factors, and personality, as well as volunteering and all outcomes in the prebaseline wave (t_0, 2006/2008). Results accounted for multiple testing and data were analyzed in 2019.

Results: During the 4-year follow-up period, participants who volunteered ≥100 hours/year (versus 0 hours/year) had a reduced risk of mortality and physical functioning limitations, higher physical activity, and better psychosocial outcomes (higher: positive affect, optimism, and purpose in life; lower: depressive symptoms, hopelessness, loneliness, and infrequent contact with friends). Volunteering was not associated with other physical health outcomes (diabetes, hypertension, stroke, cancer, heart disease, lung disease, arthritis, overweight/obesity, cognitive impairment, and chronic pain), health behaviors (binge drinking, smoking, and sleep problems), or psychosocial outcomes (life satisfaction, mastery, health/financial mastery, depression, negative affect, perceived constraints, and contact with other family/children).

Conclusions: With further research, volunteering is an activity that physicians might suggest to their willing and able patients as a way of simultaneously enhancing health and society.

Am J Prev Med 2020;59(2):176–186. *© 2020 American Journal of Preventive Medicine. Published by Elsevier Inc. All rights reserved.*

INTRODUCTION

In 2017, a total of 77 million adults in the U.S. spent 6.9 billion hours volunteering with organizations, generating $167 billion in economic value to their communities.[1] In addition to benefiting their communities, growing evidence suggests that volunteers reap health and well-being benefits from their altruistic activities. Thus, physicians and policymakers are being encouraged to prescribe volunteering to their willing and able patients as a way of simultaneously enhancing health and society.[2–4]

From the [1]Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, Massachusetts; [2]Lee Kum Sheung Center for Health and Happiness, Harvard T.H. Chan School of Public Health, Boston, Massachusetts; [3]Human Flourishing Program, Institute for Quantitative Social Science, Harvard University, Cambridge, Massachusetts; [4]Negotiation, Organizations, and Markets Unit, Harvard Business School, Cambridge, Massachusetts; [5]Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, Massachusetts; and [6]Department of Biostatistics, Harvard T.H. Chan School of Public Health, Boston, Massachusetts

Address correspondence to: Eric S. Kim, PhD, Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, 677 Huntington Avenue, Boston MA 02215. E-mail: eskim@hsph.harvard.edu.

0749-3797/$36.00
https://doi.org/10.1016/j.amepre.2020.03.004

 © 2020 American Journal of Preventive Medicine. Published by Elsevier Inc. All rights reserved.

Observational studies show that volunteering is associated with a reduced risk of functional decline,[5,6] a range of chronic conditions (e.g., reduced risk of hypertension, cardiovascular disease, and cognitive impairment),[7–9] and mortality.[6,10–15] Several mechanisms are hypothesized to underlie the salubrious effects of volunteering, including the fostering of psychological assets (e.g., increased life satisfaction, positive affect, purpose in life, self-efficacy, and reduced depression)[6,16–21] and social assets (e.g., increased perceived social support).[19] In turn, these assets might promote (1) people's ability to buffer against activation of the stress-linked neurohormonal cascade,[10,22,23] (2) healthier behaviors (e.g., increased use of preventive healthcare services),[24] and (3) better biological functioning (e.g., lower inflammation and blood pressure).[25,26] Results from experimental volunteering studies sometimes converge with results from observational studies (e.g., improved physical health [physical function and cognitive/neural function],[27–31] biological function [cholesterol and inflammation levels],[32,33] health behaviors [physical activity],[29,34–36] and psychosocial health [higher social integration, lower depression]).[27,29]

However, some results from the 2 study designs diverge (e.g., null associations with positive affect, negative affect, depressive symptoms, and life satisfaction).[32,37,38] Owing to such discrepancies, some reports indicate that there is still insufficient evidence to demonstrate a consistent influence of volunteering on various outcomes and that more research is needed before volunteering can be considered a public health intervention.[37]

These prior studies have contributed substantially to the literature. However, for volunteering to be considered a viable public health intervention,[2–4] a slightly different question must be answered that no past observational studies (that the authors are aware of) and only some experimental studies have addressed: what health and well-being outcomes might be observed within a relatively short time horizon (4-year follow-up) if people were encouraged to volunteer more?

Past observational research has been unable to address this question for several reasons. First, many studies are cross-sectional, making it challenging to assess causality. Second, some studies use data from small and specific subpopulations (e.g., college students and patient groups), and results might not generalize to older adults or healthy populations. Third, many studies do not adequately account for important potential confounders. Fourth, most longitudinal studies have not controlled for volunteering, or outcomes, in the prebaseline wave. Controlling for such variables helps readers evaluate how changes in volunteering are associated with changes in health and well-being. Experimental studies have overcome some of these limitations, but they often feature other limitations that inhibit their ability to answer this study's specific question.[39] First, most experimental studies have yet to evaluate a range of other outcomes that are core components of healthy aging. Second, many experimental studies were conducted among younger populations (e.g., high school students), and these results might not generalize to older adults (the landmark Experience Corp studies are a notable exception). Third, many studies might be underpowered to detect associations that require much larger samples. Fourth, trials often take place in artificial environments (laboratory studies), which often raise generalizability issues.[39] Fifth, most studies have short follow-up times, and it remains unknown what the effects of volunteering are on outcomes over longer durations.

Building on the seminal work of others, this study used a new outcome-wide analytic approach (described further in the Statistical Analysis section)[40] and evaluated whether changes in volunteering hours were associated with better health and well-being across 34 separate outcomes, including indicators of physical health, health behaviors, and psychosocial well-being. These outcomes were chosen because they are frequently included in the conceptualization of key gerontological models that characterize the antecedents, processes, and outcomes that foster people's ability to age well.[41–45]

METHODS

Study Population

Data were from the Health and Retirement Study (HRS), a nationally representative panel study of people aged >50 years. Starting in 2006, study staff visited a randomly selected half of the HRS participants for an enhanced face-to-face interview. The other half was assessed in 2008. After the interview, study participants were given a psychosocial questionnaire to complete and return by mail to the University of Michigan.[46] Response rates for this questionnaire were 88% in 2006 and 84% in 2008. Each subcohort alternates reporting on psychosocial factors, so that each participant reports psychosocial data every 4 years. To increase sample size and statistical power, data from both subcohorts were combined. The sample was restricted to individuals who completed the psychosocial questionnaire at baseline because more than half of study outcomes were included in this assessment; this resulted in a final sample size of 12,998.

This study used data from 3 time points (t_0, t_1, and t_2). All covariates were assessed in the prebaseline wave (t_0, 2006/2008). Then, the exposure, volunteering, was assessed 4 years later in the baseline wave (t_1, 2010/2012). Finally, all outcomes were assessed another 4 years later in the outcome wave (t_2, 2014/2016). The HRS website (hrsonline.isr.umich.edu/) provides documentation about the study. Because this study used de-identified, publicly available data, the IRB at the Harvard T.H. Chan School of Public Health exempted it from review.

Measures

Volunteering hours were assessed by asking HRS participants: *Have you spent any time in the past 12 months doing volunteer work for religious, educational, health-related, or other charitable organizations?* If they responded *yes*, then HRS asked how many hours they volunteered: *1−49 hours*, *50−99* hours, *100−199 hours*, or *≥200 hours*. Based on past research suggesting that approximately 100 hours/year of volunteering is an optimal threshold for health and well-being,[2] and to increase statistical power, the top 2 volunteering groups were collapsed in the main analyses. Results that did not collapse the top 2 volunteering groups are shown in Appendix Table 1 (available online) and results were very similar to results from the main analyses.

All covariates were assessed via self-report in the prebaseline wave (t_0, 2006/2008) and included sociodemographic factors such as age (continuous), sex (male or female), race/ethnicity (white, African American, Hispanic, and other), marital status (married or not married), annual household income (<$50,000, $50,000−$74,999, $75,000−$99,999, and ≥$100,000), total wealth (based on quintiles of the score distribution in this sample), educational attainment (no degree, GED/high school diploma, and ≥college degree), employment (yes or no), health insurance (yes or no), geographic region (Northeast, Midwest, South, and West); religious service attendance (none, once or less/week, and once or more/week); personality (openness, conscientiousness, extraversion, agreeableness, and neuroticism; continuous); and childhood abuse (yes or no).

In 2014/2016 (t_2), 34 outcomes were evaluated, including physical health factors (all-cause mortality, number of chronic conditions, diabetes, hypertension, stroke, cancer, heart disease, lung disease, arthritis, overweight/obesity, physical functioning limitations, cognitive impairment, chronic pain, and self-rated health), health behaviors (binge drinking, smoking, physical activity, and sleep problems), psychological well-being (positive affect, life satisfaction, optimism, purpose in life, mastery, health mastery, and financial mastery), psychological distress (depression, depressive symptoms, hopelessness, negative affect, and perceived constraints), and social factors (loneliness and frequency of contact with children, other family, and friends). The HRS guides (and Appendix Table 1, available online) provide further details about each assessment.[46−48]

Statistical Analysis

This study took an outcome-wide analytic approach,[40] which features several analytic decisions not widely used in disciplines outside of biostatistics and causal inference. Thus, these decisions are summarized here. First, if covariates are assessed at the same time point as the exposure (t_1), it remains unclear if the covariates are confounders or mediators[40]; thus, covariates were adjusted for in the prebaseline wave (t_0), which helps reduce this concern and allows a rich set of control variables to address confounding. Second, all outcome variables in the prebaseline wave (t_0) were adjusted for in each model to reduce potential reverse causality. Third, to evaluate change in volunteering hours, volunteering hours were adjusted for in the prebaseline wave (t_0). This helps to hold constant prebaseline levels of volunteering. Those who volunteer ≥100 hours in the prebaseline wave (t_0) and continue doing so in the baseline wave (t_1) contribute to the final estimate. However, the estimate produced from this analysis also corresponds to those who did not volunteer in t_0 and start volunteering ≥100 hours in t_1. The model effectively assumes that the coefficient for ≥100 hours of volunteering is constant across past volunteering levels (i.e., no interaction between past and current volunteering). Thus, readers are able to evaluate how changes in volunteering hours (between t_0 and t_1) are associated with subsequent health and well-being outcomes (at t_2; Appendix Table 2, available online, provides further details). Controlling for prebaseline levels of volunteering (t_0) also has several other advantages, including helping to reduce the risk of reverse causality by removing the accumulating effects that volunteering already had on outcomes in the past (prevalent exposure) and allowing readers to instead focus on the effects of change in volunteering hours (incident exposure) on outcomes; thus, the focus is on how short-term changes in volunteering are associated with short-term changes in the outcomes.

Separate models were run for each outcome. Depending on the nature of the outcome, a different model was run: (1) for each binary outcome with a prevalence <10%, logistic regression was used; (2) for each binary outcome with a prevalence ≥10%, generalized linear model (with a log link and Poisson distribution) was used; and (3) for each continuous outcome, a linear regression model was used. Further, each continuous outcome was standardized (mean=0, SD=1) so their effect size could be interpreted in terms of SD change in the outcome variable. In the tables, multiple *p*-value cut offs were marked because practices for multiple testing vary widely and this is an evolving research area.[49,50] All data were analyzed in 2019.

Several additional analyses were conducted. First, to assess the robustness of the volunteering−health/well-being associations to unmeasured confounding, *E*-values were calculated to assess the minimum strength that unmeasured confounding must have on the RR scale (with both volunteering and the outcome) to entirely explain the association away.[51] Second, all models were reanalyzed using a reduced list of covariates that are more conventionally used in the volunteering−health/well-being literature (e.g., sociodemographic factors). This analytic approach asks a different question: what are the potential long-term cumulative effects that the whole history of volunteering (approximated by its current measure, but not controlling for the past) has on outcomes? Third, the main models were reanalyzed but first removed people with a history of any given physical condition at baseline. Fourth, all models were reanalyzed using only complete cases to evaluate the impact of multiple imputation on results.

All missing data on the exposure, covariates, and outcomes were imputed using an imputation by chained equations approach, and 5 data sets were created. This approach was chosen because it provides a more flexible approach than many other methods of handling missing data[52−54] and helps address problems that emerge because of attrition.[55−60]

RESULTS

In the covariate wave (t_0, 2006/2008) participants were aged 66 (SD=10) years on average, mostly women (59%), and married (66%). Table 1 provides the distribution of covariates by volunteering hours. Appendix Table 2 (available online) describes the change in volunteering hours from t_0 to t_1.

Table 1. Characteristics of Participants at Baseline by Categories of Volunteering (*n*=10,979)

	Hours of volunteering/year							
	0 hours/year (*n*=6,714)		1–49 hours/year (*n*=1,336)		50–99 hours/year (*n*=967)		≥100 hours/year (*n*=1,962)	
Participant characteristics	***n* (%)**	**Mean (SD)**	***n* (%)**	**Mean (SD)**	***n* (%)**	**Mean (SD)**	***n* (%)**	**Mean (SD)**
Sociodemographic factors								
Age, years (range: 46–99)		68.1 (9.6)		67.3 (9.5)		67.6 (9.5)		68.4 (9.0)
Female	3,903 (58.1)		829 (62.1)		609 (63.0)		1,199 (61.1)	
Race/ethnicity								
White	5,051 (75.2)		1,072 (80.2)		800 (82.7)		1,645 (83.4)	
Black	805 (12.0)		162 (12.1)		113 (11.7)		219 (11.2)	
Hispanic	677 (10.1)		73 (5.5)		38 (3.9)		70 (3.6)	
Other	180 (2.7)		29 (2.2)		16 (1.7)		28 (1.4)	
Married	4,256 (63.4)		916 (68.6)		686 (70.9)		1,450 (73.9)	
Annual household income								
<$50,000	4,121 (61.4)		650 (48.7)		456 (47.2)		916 (46.7)	
$50,000–$74,999	1,034 (15.4)		222 (16.6)		156 (16.1)		372 (19.7)	
$75,000–$99,999	593 (8.8)		151 (11.3)		105 (10.9)		251 (12.8)	
≥$100,000	966 (14.4)		313 (23.4)		250 (25.9)		423 (21.6)	
Total wealth								
1st quintile	1,655 (24.7)		198 (14.8)		120 (12.4)		219 (11.2)	
2nd quintile	1,461 (21.8)		253 (18.9)		160 (16.6)		329 (16.8)	
3rd quintile	1,297 (19.3)		286 (21.4)		205 (21.2)		401 (20.4)	
4th quintile	1,209 (18.0)		296 (22.2)		232 (24.0)		462 (23.6)	
5th Quintile	1,092 (16.3)		303 (22.7)		250 (25.9)		551 (28.1)	
Education								
Less than high school	1,481 (22.1)		135 (10.2)		82 (8.5)		144 (7.4)	
High school	3,822 (57.1)		749 (56.4)		526 (54.5)		967 (49.5)	
At least some college	1,395 (20.8)		445 (33.5)		357 (37.0)		841 (43.1)	
Employed	2,658 (39.6)		662 (49.6)		476 (49.2)		791 (40.3)	
Health insurance	5,820 (86.8)		1,146 (85.8)		825 (85.4)		1,720 (87.7)	
Geographic region								
Northeast	1,067 (15.9)		171 (12.8)		121 (12.5)		285 (14.6)	
Midwest	1,670 (24.9)		435 (32.6)		302 (31.2)		554 (28.3)	
South	2,691 (40.2)		500 (37.5)		347 (35.9)		743 (38.0)	
West	1,274 (19.0)		229 (17.2)		197 (20.4)		375 (19.2)	
Childhood abuse	436 (7.2)		78 (6.3)		56 (6.3)		117 (6.4)	
Physical health								
Diabetes	1,311 (20.0)		214 (16.1)		105 (10.9)		296 (15.1)	
Hypertension	3,693 (55.1)		680 (51.0)		491 (51.0)		1,001 (51.1)	
Stroke	438 (6.5)		63 (4.7)		47 (4.9)		94 (4.8)	
Cancer	946 (14.0)		166 (12.5)		128 (13.3)		253 (12.9)	
Heart disease	1,417 (21.2)		249 (18.7)		175 (18.1)		383 (19.6)	
Lung disease	602 (9.0)		80 (6.0)		50 (5.2)		109 (5.6)	
Arthritis	3,925 (58.5)		745 (55.8)		538 (55.7)		1,101 (56.2)	
Overweight/obesity	4,817 (72.8)		943 (71.3)		676 (70.8)		1,376 (70.7)	
Physical function limitations	1,562 (23.3)		195 (14.6)		125 (12.9)		237 (12.1)	
Cognitive impairment	1,170 (17.8)		138 (10.4)		86 (9.0)		129 (6.6)	
Chronic pain	2,448 (36.5)		398 (29.8)		291 (30.1)		516 (26.3)	
Self-rated health (range: 1–5)		3.1 (1.1)		3.5 (1.0)		3.5 (0.9)		3.6 (1.0)
Health behaviors								
Binge drinking	793 (14.5)		148 (14.2)		96 (12.0)		157 (9.9)	

(*continued on next page*)

Table 1. Characteristics of Participants at Baseline by Categories of Volunteering (*n*=10,979) (*continued*)

	Hours of volunteering/year							
	0 hours/year (*n*=6,714)		1–49 hours/year (*n*=1,336)		50–99 hours/year (*n*=967)		≥100 hours/year (*n*=1,962)	
Participant characteristics	***n* (%)**	**Mean (SD)**	***n* (%)**	**Mean (SD)**	***n* (%)**	**Mean (SD)**	***n* (%)**	**Mean (SD)**
Smoking	1,092 (16.4)		107 (8.1)		67 (7.0)		106 (5.4)	
Frequent physical activity	4,818 (71.8)		1,070 (80.2)		809 (83.7)		1,688 (86.1)	
Sleep problems	1,559 (42.8)		296 (40.3)		216 (40.5)		386 (34.6)	
Religious service attendance								
Never	2,200 (33.1)		139 (10.4)		82 (8.5)		180 (9.2)	
<1×/week	2,466 (36.8)		425 (31.9)		262 (27.1)		407 (20.8)	
≥1×/week	2,023 (30.2)		770 (57.7)		622 (64.4)		1,374 (70.1)	
Psychological well-being								
Positive affect (range: 1–5)		3.5 (0.8)		3.7 (0.7)		3.8 (0.7)		3.8 (0.6)
Life satisfaction (range: 1–7)		4.9 (1.5)		5.2 (1.4)		5.4 (1.3)		5.5 (1.3)
Optimism (range: 1–6)		4.4 (1.0)		4.6 (0.9)		4.8 (0.9)		4.8 (0.9)
Purpose in life (range: 1–6)		4.5 (0.9)		4.8 (0.8)		4.9 (0.8)		4.9 (0.8)
Mastery (range: 1–6)		4.8 (1.1)		4.9 (1.0)		4.9 (1.0)		4.9 (1.0)
Health mastery (range: 1–10)		7.3 (2.4)		7.5 (2.1)		7.6 (2.0)		7.7 (1.9)
Financial mastery (range: 1–10)		7.3 (2.7)		7.5 (2.4)		7.6 (2.3)		7.7 (2.2)
Psychological distress								
Depression	1,016 (15.5)		117 (8.8)		75 (7.9)		115 (5.9)	
Depressive symptoms (range: 0–8)		1.5 (2.0)		1.0 (1.7)		0.9 (1.5)		0.8 (1.4)
Hopelessness (range: 1–6)		2.5 (1.3)		2.1 (1.2)		1.9 (1.0)		1.9 (1.0)
Negative affect (range: 1–5)		1.7 (0.7)		1.6 (0.6)		1.6 (0.5)		1.5 (0.5)
Perceived constraints (range: 1–6)		2.2 (1.2)		2.0 (1.0)		1.9 (1.0)		1.9 (1.0)
Social factors								
Loneliness (range: 1–3)	1.5 (0.6)		1.4 (0.5)		1.4 (0.5)		1.3 (0.5)	
Living with spouse/partner	4,054 (67.8)		882 (72.1)		653 (73.0)		1,373 (76.1)	
Contact children <1×/week	1,578 (26.2)		270 (22.2)		193 (22.0)		407 (22.7)	
Contact other family <1×/week	2,882 (47.7)		584 (47.6)		418 (46.9)		887 (49.0)	
Contact friends <1×/week	2,423 (39.9)		370 (30.1)		231 (25.7)		399 (22.0)	
Personality								
Openness (range: 1–4)		2.9 (0.6)		3.0 (0.5)		3.1 (0.5)		3.1 (0.5)
Conscientiousness (range: 1–4)		3.4 (0.5)		3.4 (0.4)		3.4 (0.4)		3.5 (0.4)
Extraversion (range: 1–4)		3.1 (0.6)		3.3 (0.5)		3.3 (0.5)		3.4 (0.5)
Agreeableness (range: 1–4)		3.5 (0.5)		3.6 (0.4)		3.6 (0.4)		3.6 (0.4)
Neuroticism (range: 1–4)		2.1 (0.6)		2.0 (0.6)		2.0 (0.6)		1.9 (0.6)

Note: This table was created based on non-imputed data. All variables in Table 1 were used as covariates and assessed in the prebaseline wave (t_0, 2006/2008).

During the 4-year follow-up period, those volunteering ≥100 hours/year (versus 0 hours/year) had 44% reduced risk of mortality (95% CI=0.44, 0.71), 17% reduced risk of physical functioning limitations (95% CI=0.72, 0.96), and higher self-rated health (β=0.14, 95% CI=0.08, 0.19) (Table 2). There was no evidence that volunteering was associated with other physical health outcomes, including number of chronic conditions, diabetes, hypertension, stroke, cancer, heart disease, lung disease, arthritis, overweight/obesity, cognitive impairment, or chronic pain. When considering health behaviors, volunteering was associated with 12% increased likelihood of frequent physical activity (95% CI=1.03, 1.23) but not associated with binge drinking, smoking, or sleep problems. Among psychological factors, those volunteering ≥100 hours/year (versus 0 hours/year) had higher positive affect (β=0.13, 95% CI=0.08, 0.19), optimism (β=0.06, 95% CI=0.00, 0.12), and purpose in life (β=0.11, 95% CI=0.05, 0.16), as well as lower depressive symptoms (β= −0.06, 95% CI= −0.11, 0.00) and hopelessness (β= −0.08, 95% CI= −0.14, −0.02). However, there was no evidence that volunteering was associated with life satisfaction, mastery, health mastery, financial mastery, depression, negative

affect, or perceived constraints. Finally, among social factors, those volunteering ≥100 hours/year (versus 0 hours/year) had lower loneliness (β= −0.06, 95% CI= −0.13, 0.09) and were 29% less likely to report lack of contact with friends (95% CI=0.62, 0.80). For the volunteering ≥100 hours/year group, although associations with physical functioning limitations, frequent physical activity, optimism, depressive symptoms, hopelessness, and loneliness met conventional $p<0.05$ thresholds, they did not do so after Bonferroni correction. By contrast, associations with all-cause mortality, self-rated health, positive affect, purpose in life, and contact with friends did surpass the $p<0.05$ threshold even after Bonferroni correction.

First, *E*-values suggested that several of the observed associations were at least moderately robust to unmeasured confounding (Table 3). Second, conventionally adjusted covariates models showed estimates that

Table 2. Volunteering and Subsequent Health and Well-Being (HRS, *n*=12,998)

	Hours of volunteering/year			
Variable	**0 hours/year (*n*=8,064) (Ref)**	**1–49 hours/year (*n*=1,794) RR/OR/β (95% CI)**	**50–99 hours/year (*n*=1,150) RR/OR/β (95% CI)**	**≥100 hours/year (*n*=1,990) RR/OR/β (95% CI)**
Physical health				
All-cause mortality	1.00	0.85 (0.70, 1.04)	**0.72 (0.55, 0.93)***	**0.56 (0.44, 0.71)*****
Number of chronic conditions	0.00	−0.03 (−0.06, 0.00)	**−0.08 (−0.12, −0.04)*****	−0.03 (−0.07, 0.01)
Diabetes	1.00	0.98 (0.88, 1.10)	0.91 (0.79, 1.05)	0.91 (0.80, 1.03)
Hypertension	1.00	0.99 (0.92, 1.06)	0.97 (0.89, 1.06)	1.00 (0.93, 1.09)
Stroke	1.00	1.08 (0.91, 1.29)	0.87 (0.67, 1.12)	0.90 (0.73, 1.12)
Cancer	1.00	0.99 (0.87, 1.12)	0.90 (0.77, 1.05)	0.92 (0.81, 1.06)
Heart disease	1.00	1.01 (0.90, 1.12)	0.94 (0.82, 1.07)	0.95 (0.84, 1.06)
Lung disease	1.00	0.91 (0.76, 1.08)	0.97 (0.78, 1.21)	1.05 (0.87, 1.27)
Arthritis	1.00	0.98 (0.92, 1.05)	0.99 (0.91, 1.08)	1.02 (0.95, 1.11)
Overweight/obesity	1.00	0.98 (0.92, 1.05)	0.99 (0.90, 1.08)	1.01 (0.94, 1.09)
Physical functioning limitations	1.00	0.99 (0.89, 1.10)	**0.84 (0.72, 0.98)***	**0.83 (0.72, 0.96)***
Cognitive impairment	1.00	0.91 (0.79, 1.06)	**0.83 (0.71, 0.98)***	0.86 (0.73, 1.00)
Chronic pain	1.00	0.99 (0.91, 1.09)	0.96 (0.86, 1.08)	0.95 (0.85, 1.06)
Self-rated health	0.00	0.04 (0.00, 0.09)	**0.09 (0.03, 0.15)****	**0.14 (0.08, 0.19)*****
Health behaviors				
Binge drinking	1.00	0.98 (0.72, 1.32)	0.98 (0.64, 1.49)	0.92 (0.58, 1.48)
Smoking	1.00	0.79 (0.58, 1.08)	0.87 (0.60, 1.27)	0.89 (0.58, 1.36)
Frequent physical activity	1.00	1.04 (0.96, 1.13)	1.06 (0.96, 1.17)	**1.12 (1.03, 1.23)****
Sleep problems	1.00	0.99 (0.90, 1.09)	1.02 (0.91, 1.14)	0.99 (0.89, 1.11)
Psychological well-being				
Positive affect	0.00	0.04 (−0.02, 0.09)	**0.09 (0.03, 0.15)****	**0.13 (0.08, 0.19)*****
Life satisfaction	0.00	0.00 (−0.05, 0.05)	−0.02 (−0.10, 0.06)	0.05 (−0.03, 0.13)
Optimism	0.00	0.03 (−0.02, 0.08)	0.03 (−0.03, 0.09)	**0.06 (0.00, 0.12)***
Purpose in life	0.00	0.03 (−0.02, 0.09)	0.06 (0.00, 0.13)	**0.11 (0.05, 0.16)*****
Mastery	0.00	0.01 (−0.05, 0.07)	0.00 (−0.08, 0.08)	0.08 (−0.01, 0.17)
Health mastery	0.00	0.01 (−0.05, 0.07)	0.01 (−0.08, 0.10)	0.05 (−0.04, 0.14)
Financial mastery	0.00	0.02 (−0.05, 0.08)	0.03 (−0.04, 0.11)	0.08 (−0.03, 0.19)
Psychological distress				
Depression	1.00	0.92 (0.77, 1.09)	0.92 (0.71, 1.19)	0.90 (0.73, 1.12)
Depressive symptoms	0.00	−0.05 (−0.09, 0.00)	**−0.06 (−0.13, −0.01)***	**−0.06 (−0.11, 0.00)***
Hopelessness	0.00	−0.04 (−0.09, 0.01)	−0.05 (−0.11, 0.02)	**−0.08 (−0.14, −0.02)***
Negative affect	0.00	0.02 (−0.03, 0.07)	0.01 (−0.06, 0.08)	−0.01 (−0.08, 0.06)
Perceived constraints	0.00	−0.03 (−0.09, 0.03)	−0.03 (−0.10, 0.05)	−0.06 (−0.13, 0.02)
Social factors				
Loneliness	0.00	0.00 (−0.05, 0.04)	−0.06 (−0.12, 0.00)	**−0.06 (−0.13, −0.00)***
Contact children <1×/week	1.00	0.95 (0.85, 1.05)	0.94 (0.81, 1.09)	0.99 (0.86, 1.13)

(*continued on next page*)

Table 2. Volunteering and Subsequent Health and Well-Being (HRS, *n*=12,998) (*continued*)

Variable	Hours of volunteering/year			
	0 hours/year (*n*=8,064) (Ref)	1–49 hours/year (*n*=1,794) RR/OR/β (95% CI)	50–99 hours/year (*n*=1,150) RR/OR/β (95% CI)	≥100 hours/year (*n*=1,990) RR/OR/β (95% CI)
Contact other family <1×/week	1.00	0.99 (0.92, 1.08)	1.00 (0.89, 1.12)	1.07 (0.98, 1.17)
Contact friends <1×/week	1.00	**0.88 (0.79, 0.98)***	**0.83 (0.73, 0.94)****	**0.71 (0.62, 0.80)*****

Note: Boldface indicates statistical significance (
*p<0.05 before Bonferroni correction;
**p<0.01 before Bonferroni correction;
***p<0.05 after Bonferroni correction [the p-value cutoff for Bonferroni correction is p=0.05/34 outcomes=p<0.001]).
If the reference value is 1, the effect estimate is OR or RR; if the reference value is 0, the effect estimate is β.
The analytic sample was restricted to those who had participated in the baseline wave (t_1, 2010 or 2012). Multiple imputation was performed to impute missing data on the exposure, covariates, and outcomes. All models controlled for sociodemographic characteristics (age, sex, race/ethnicity, marital status, annual household income, total wealth, level of education, employment status, health insurance, and geographic region), prebaseline childhood abuse, prebaseline religious service attendance, prebaseline values of the outcome variables (diabetes, hypertension, stroke, cancer, heart disease, lung disease, arthritis, overweight/obesity, physical functioning limitations, cognitive impairment, chronic pain, self-rated health, binge drinking, current smoking status, physical activity, sleep problems, positive affect, life satisfaction, optimism, purpose in life, mastery, health mastery, financial mastery, depressive symptoms, hopelessness, negative affect, perceived constraints, loneliness, living with spouse/partner, contact with children <1×/week, contact with other family <1×/week, and contact with friends <1×/week), personality factors (openness, conscientiousness, extraversion, agreeableness, and neuroticism), and the prebaseline value of the exposure. These variables were controlled for in the wave prebaseline to the exposure assessment (in t_0, 2006 or 2008).
An outcome-wide analytic approach was used, and a separate model for each outcome was run. A different type of model was run depending on the nature of the outcome: (1) for each binary outcome with a prevalence of ≥10%, a generalized linear model (with a log link and Poisson distribution) was used to estimate a RR; (2) for each binary outcome with a prevalence of <10%, a logistic regression model was used to estimate an OR; and (3) for each continuous outcome, a linear regression model was used to estimate a β.
All continuous outcomes were standardized (mean=0; SD=1), and β was the standardized effect size.
HRS, Health and Retirement Study.

generally had larger coefficients than fully adjusted models (Appendix Table 3, available online). Third, when reanalyzing the fully adjusted models after removing anyone with history of a given physical condition at baseline, estimates generally had larger coefficients (Appendix Table 3, available online). Complete-case analyses provided similar results to results in the main analyses (Appendix Table 4, available online). Finally, an illustrative table was created to display coefficient estimates of all study variables, including covariates, for 1 of the outcomes: mortality (Appendix Table 5, available online).

DISCUSSION

In a large, longitudinal, and nationally representative sample of adults aged >50 years, those volunteering ≥100 hours/year (versus 0 hours/year) had a substantially reduced risk of mortality and onset of physical functioning limitations, better self-rated health, and higher physical activity. However, volunteering was not associated with 10 other physical health outcomes or 3 health behaviors. Further, volunteering ≥100 hours/year (versus 0 hours/year) was associated with better outcomes on some indicators of psychosocial well-being (e.g., higher purpose in life) but not others (e.g., negative affect). In line with prior work,[2] many volunteering–health/well-being associations emerged only among people who volunteered ≥100 hours/year, suggesting evidence of a threshold effect.

Results from this study both converge with (e.g., associations with mortality, physical functioning, physical activity, positive affect, and purpose) and diverge from results from past research (no associations with specific health outcomes such as heart disease and cognitive impairment). As one illustrative example, volunteering was associated with higher positive affect, and this finding both converges with[18,19] and diverges from[32,38] some prior research. Methodologically, the underlying reasons for diverging results might be attributable to several sources, including differences in (1) study design (observational versus experimental), (2) composition of the sample (e.g., past work suggests that the volunteering–psychological well-being association is stronger in older adults,[61] and most experimental work on positive affect outcomes has focused on younger adults, whereas most observational work has focused on older adults), (3) measurement and categorization of the exposure and outcome, (4) inclusion or exclusion of covariates, and (5) control or no control for prebaseline volunteering and outcome(s).

These diverging results also highlight how future research should consider important candidate moderators of the volunteering–health/well-being association, including age,[61] SES,[32] social connection,[62] depression,[63] baseline health,[38] personality,[10] motivations for

Table 3. Robustness to Unmeasured Confounding (*E*-Values) for the Associations Between Volunteering (≥100 Hours/Year versus 0 Hours/Year) and Subsequent Health and Well-Being (*n*=12,998)

Variable	Effect estimate[a]	CI limit[b]
Physical health		
All-cause mortality	2.97	2.17
Number of chronic conditions	1.20	1.00
Diabetes	1.43	1.00
Hypertension	1.00	1.00
Stroke	1.46	1.00
Cancer	1.39	1.00
Heart disease	1.29	1.00
Lung disease	1.28	1.00
Arthritis	1.16	1.00
Overweight/obesity	1.11	1.00
Physical functioning limitations	1.70	1.25
Cognitive impairment	1.60	1.00
Chronic pain	1.29	1.00
Self-rated health	1.52	1.36
Health behaviors		
Binge drinking	1.39	1.00
Smoking	1.50	1.00
Frequent physical activity	1.49	1.21
Sleep problems	1.11	1.00
Psychological well-being		
Positive affect	1.51	1.37
Life satisfaction	1.27	1.00
Optimism	1.30	1.05
Purpose in life	1.44	1.27
Mastery	1.36	1.00
Health mastery	1.26	1.00
Financial mastery	1.37	1.00
Psychological distress		
Depression	1.43	1.00
Depressive symptoms	1.29	1.07
Hopelessness	1.36	1.16
Negative affect	1.10	1.00
Perceived constraints	1.29	1.00
Social factors		
Loneliness	1.31	1.06
Contact children <1×/week	1.11	1.00
Contact other family <1×/week	1.34	1.00
Contact friends <1×/week	2.17	1.81

Note: See VanderWeele and Ding (2017) for the formula for calculating *E*-values.

[a]The *E*-values for effect estimates are the minimum strength of association on the risk ratio scale that an unmeasured confounder would need to have with both the exposure and the outcome to fully explain away the observed association between the exposure and outcome, conditional on the measured covariates.

[b]The *E*-values for the limit of the 95% CI closest to the null denote the minimum strength of association on the risk ratio scale that an unmeasured confounder would need to have with both the exposure and the outcome to shift the CI to include the null value, conditional on the measured covariates.

volunteering,[11] and type and quality of the volunteering experience.[64] Some of these factors might also act as important mechanistic pathways and should be evaluated formally as such.

In this study, people who volunteered ≥100 hours/year (versus 0 hours/year) had a substantially reduced risk of mortality, yet volunteering was not associated with most physical health indicators. Several factors might explain this perplexing observation. First, volunteering was associated with several biopsychosocial mechanisms that past research has identified as independent risk or protective factors for mortality risk (e.g., physical activity and purpose in life).[65,66] Second, although data on incidence of chronic conditions were captured, specific causes of death data were missed. A study participant could have been stroke free throughout their life but died of stroke and such information was missed. HRS collects information about some causes of death, but the categories do not map cleanly onto the chronic condition categories that were evaluated; thus, composite variables that capture both incidence of disease and death because of disease were not created (Appendix Table 3, available online, provides further details). Third, emerging research suggests that important factors moderate the volunteering–mortality association (e.g., self- versus other-focused motivations for volunteering and belief that others are fundamentally good or bad),[10,11] and future research should evaluate if such factors also moderate associations between volunteering and chronic conditions. Fourth, when considering the top causes of death among older adults (e.g., injury, pneumonia/influenza, or suicide), many causes are not well captured by existing HRS assessments of health/well-being.

Limitations

Many variables were self-reported and thus vulnerable to self-report bias. However, study participants were unaware of this study's hypothesis when completing the HRS survey and volunteering was reported before the assessment of outcomes. Future research should evaluate the outcomes using objective assessments. Confounding by unmeasured third variables is a limitation, but the prospective nature of the data, robust covariate control, and *E*-value analyses help reduce this concern. In the main analyses, all participants were included at baseline, even if they had chronic conditions. Thus, incidence of a condition was evaluated. To help further isolate incidence, secondary analyses were conducted, and they removed people with a given condition at baseline. Reoccurrence could not be evaluated because the HRS only asks if a person ever had a condition. Although some study outcomes were correlated, there were unique and

differential associations between volunteering and closely related outcomes. For example, volunteering was associated with positive affect but not life satisfaction. Such differential findings provide some evidence that the associations are not entirely induced by correlated outcomes. Further, even if the effect of volunteering on some outcomes impacts other outcomes, this is important information for health promotion because correlated outcomes might highlight potential mediators that can be formally evaluated in future work (e.g., reduced loneliness might lead to increased positive affect). The study also had several strengths including the use of a large, diverse, prospective, and nationally representative sample of U.S. adults aged >50 years. Further, incident rather than prevalent exposure was evaluated, and this provides stronger evidence for causality around this study's main question of interest.[67–69]

CONCLUSIONS

Volunteering ≥100 hours/year (approximately 2 hours/week) was associated with a reduced risk of mortality and physical functioning limitations, higher physical activity, and several beneficial psychosocial outcomes. The growing older adult population possesses a vast array of skills and experiences that can be leveraged for the greater good of society via volunteering. With further research, policies and interventions aimed at encouraging more volunteering it might be an innovative way of simultaneously enhancing society and fostering a trajectory of healthy aging (on some indicators) in the large and rapidly growing population of older adults.[3]

ACKNOWLEDGMENTS

The authors would like to thank the Health and Retirement Study, which is conducted by the University of Michigan's Institute for Social Research, with grants from the National Institute on Aging (U01AG09740) and Social Security Administration. This work was supported by grants from the NIH (K99AG055696) and from the John Templeton Foundation (61075). The authors also thank the Editors and anonymous reviewers as they helped substantially improve the manuscript with their insightful comments.

All authors 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; all authors contributed to the study concept and design; all authors contributed to acquisition, analysis, or interpretation of data; ESK contributed to drafting the manuscript; and all authors contributed to critical revision of the manuscript for important intellectual content.

ESK has worked as a consultant with AARP and UnitedHealth Group. Tyler J. VanderWeele has worked as a consultant for Aetna Inc. No other financial disclosures were reported by the authors of this paper.

SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2020.03.004.

REFERENCES

1. Volunteering in America: research. Corporation for National & Community Service. www.nationalservice.gov/serve/via/research. Accessed June 10, 2019.
2. Johnson SS, Post SG. Rx it's good to be good (B2BG) 2017 commentary: prescribing volunteerism for health, happiness, resilience, and longevity. *Am J Health Promot.* 2017;31(2):164–172. https://doi.org/10.1177/0890117117691705.
3. Carr DC, Fried LP, Rowe JW. Productivity & engagement in an aging America: the role of volunteerism. *Daedalus.* 2015;144(2):55–67. https://doi.org/10.1162/DAED_a_00330.
4. Morrow-Howell N, Backes K, O'Neill G, Greenfield JC. Volunteering in later life: policies and programs to support a resilient aging society. In: Resnick B, Gwyther LP, Roberto KA, eds. *Resilience in Aging: Concepts, Research, and Outcomes.* Cham, Switzerland: Springer International, 2018:171–189. https://doi.org/10.1007/978-3-030-04555-5_9.
5. Carr DC, Kail BL, Rowe JW. The relation of volunteering and subsequent changes in physical disability in older adults. *J Gerontol B Psychol Sci Soc Sci.* 2018;73(3):511–521. https://doi.org/10.1093/geronb/gbx102.
6. Anderson ND, Damianakis T, Kröger E, et al. The benefits associated with volunteering among seniors: a critical review and recommendations for future research. *Psychol Bull.* 2014;140(6):1505–1533. https://doi.org/10.1037/a0037610.
7. Burr JA, Tavares J, Mutchler JE. Volunteering and hypertension risk in later life. *J Aging Health.* 2011;23(1):24–51. https://doi.org/10.1177/0898264310388272.
8. Burr JA, Han SH, Tavares JL. Volunteering and cardiovascular disease risk: does helping others get "under the skin? *Gerontologist.* 2016;56(5):937–947. https://doi.org/10.1093/geront/gnv032.
9. Infurna FJ, Okun MA, Grimm KJ. Volunteering is associated with lower risk of cognitive impairment. *J Am Geriatr Soc.* 2016;64(11):2263–2269. https://doi.org/10.1111/jgs.14398.
10. Poulin MJ. Volunteering predicts health among those who value others: two national studies. *Health Psychol.* 2014;33(2):120–129. https://doi.org/10.1037/a0031620.
11. Konrath S, Fuhrel-Forbis A, Lou A, Brown S. Motives for volunteering are associated with mortality risk in older adults. *Health Psychol.* 2012;31(1):87–96. https://doi.org/10.1037/a0025226.
12. Musick MA, Herzog AR, House JS. Volunteering and mortality among older adults: findings from a national sample. *J Gerontol B Psychol Sci Soc Sci.* 1999;54(3):S173–S180. https://doi.org/10.1093/geronb/54B.3.S173.
13. Oman D, Thoresen CE, McMahon K. Volunteerism and mortality among the community-dwelling elderly. *J Health Psychol.* 1999;4(3):301–316. https://doi.org/10.1177/135910539900400301.
14. Luoh MC, Herzog AR. Individual consequences of volunteer and paid work in old age: health and mortality. *J Health Soc Behav.* 2002;43(4):490–509. https://doi.org/10.2307/3090239.
15. Sabin EP. Social relationships and mortality among the elderly. *J Appl Gerontol.* 1993;12(1):44–60. https://doi.org/10.1177/073346489301200105.
16. Morrow-Howell N, Hinterlong J, Rozario PA, Tang F. Effects of volunteering on the well-being of older adults. *J Gerontol B Psychol Sci Soc Sci.* 2003;58(3):S137–S145. https://doi.org/10.1093/geronb/58.3.s137.
17. Tabassum F, Mohan J, Smith P. Association of volunteering with mental well-being: a lifecourse analysis of a national population-based longitudinal study in the UK [published correction appears in *BMJ*

Open. 2016;6(9):e011327corr1]. *BMJ Open*. 2016;6(8):e011327. https://doi.org/10.1136/bmjopen-2016-011327.
18. Greenfield EA, Marks NF. Formal volunteering as a protective factor for older adults' psychological well-being. *J Gerontol B Psychol Sci Soc Sci*. 2004;59(5):S258–S264. https://doi.org/10.1093/geronb/59.5.s258.
19. Pilkington PD, Windsor TD, Crisp DA. Volunteering and subjective well-being in midlife and older adults: the role of supportive social networks. *J Gerontol B Psychol Sci Soc Sci*. 2012;67(2):249–260. https://doi.org/10.1093/geronb/gbr154.
20. Müller D, Ziegelmann JP, Simonson J, Tesch-Römer C, Huxhold O. Volunteering and subjective well-being in later adulthood: is self-efficacy the key? *Int J Dev Sci*. 2014;8(3–4):125–135. https://doi.org/10.3233/DEV-14140.
21. Aknin L, Whillans AV, Norton MI, Dunn EW. Happiness and prosocial behavior: an evaluation of the evidence. In: Helliwell JF, Layard R, Sachs JD, eds. *World Happiness Report 2019*. New York, NY: Sustainable Development Solutions Network, 2019:66–85. https://s3.amazonaws.com/happiness-report/2019/WHR19_Ch4.pdf . Accessed January 10, 2020.
22. Han SH, Kim K, Burr JA. Stress-buffering effects of volunteering on salivary cortisol: results from a daily diary study. *Soc Sci Med*. 2018;201:120–126. https://doi.org/10.1016/j.socscimed.2018.02.011.
23. Raposa EB, Laws HB, Ansell EB. Prosocial behavior mitigates the negative effects of stress in everyday life. *Clin Psychol Sci*. 2016;4(4):691–698. https://doi.org/10.1177/2167702615611073.
24. Kim ES, Konrath SH. Volunteering is prospectively associated with health care use among older adults. *Soc Sci Med*. 2016;149:122–129. https://doi.org/10.1016/j.socscimed.2015.11.043.
25. Kim S, Ferraro KF. Do productive activities reduce inflammation in later life? Multiple roles, frequency of activities, and C-reactive protein. *Gerontologist*. 2014;54(5):830–839. https://doi.org/10.1093/geront/gnt090.
26. Sneed RS, Cohen S. A prospective study of volunteerism and hypertension risk in older adults. *Psychol Aging*. 2013;28(2):578–586. https://doi.org/10.1037/a0032718.
27. Hong SI, Morrow-Howell N. Health outcomes of Experience Corps: a high-commitment volunteer program. *Soc Sci Med*. 2010;71(2):414–420. https://doi.org/10.1016/j.socscimed.2010.04.009.
28. Barron JS, Tan EJ, Yu Q, Song M, McGill S, Fried LP. Potential for intensive volunteering to promote the health of older adults in fair health. *J Urban Health*. 2009;86(4):641–653. https://doi.org/10.1007/s11524-009-9353-8.
29. Fried LP, Carlson MC, Freedman M, et al. A social model for health promotion for an aging population: initial evidence on the Experience Corps model. *J Urban Health*. 2004;81(1):64–78. https://doi.org/10.1093/jurban/jth094.
30. Carlson MC, Kuo JH, Chuang YF, et al. Impact of the Baltimore Experience Corps Trial on cortical and hippocampal volumes. *Alzheimers Dement*. 2015;11(11):1340–1348. https://doi.org/10.1016/j.jalz.2014.12.005.
31. Carlson MC, Saczynski JS, Rebok GW, et al. Exploring the effects of an "everyday" activity program on executive function and memory in older adults: Experience Corps®. *Gerontologist*. 2008;48(6):793–801. https://doi.org/10.1093/geront/48.6.793.
32. Schreier HM, Schonert-Reichl KA, Chen E. Effect of volunteering on risk factors for cardiovascular disease in adolescents: a randomized controlled trial. *JAMA Pediatr*. 2013;167(4):327–332. https://doi.org/10.1001/jamapediatrics.2013.1100.
33. Nelson-Coffey SK, Fritz MM, Lyubomirsky S, Cole SW. Kindness in the blood: a randomized controlled trial of the gene regulatory impact of prosocial behavior. *Psychoneuroendocrinology*. 2017;81:8–13. https://doi.org/10.1016/j.psyneuen.2017.03.025.
34. Varma VR, Tan EJ, Gross AL, et al. Effect of community volunteering on physical activity: a randomized controlled trial. *Am J Prev Med*. 2016;50(1):106–110. https://doi.org/10.1016/j.amepre.2015.06.015.
35. Parisi JM, Kuo J, Rebok GW, et al. Increases in lifestyle activities as a result of Experience Corps® participation. *J Urban Health*. 2015;92(1):55–66. https://doi.org/10.1007/s11524-014-9918-z.
36. Tan EJ, Xue QL, Li T, Carlson MC, Fried LP. Volunteering: a physical activity intervention for older adults—the Experience Corps program in Baltimore. *J Urban Health*. 2006;83(5):954–969. https://doi.org/10.1007/s11524-006-9060-7.
37. Jenkinson CE, Dickens AP, Jones K, et al. Is volunteering a public health intervention? A systematic review and meta-analysis of the health and survival of volunteers. *BMC Public Health*. 2013;13:773. https://doi.org/10.1186/1471-2458-13-773.
38. Whillans AV, Seider SC, Chen L, et al. Does volunteering improve well-being? *Compr Results Soc Psychol*. 2016;1(1–3):35–50. https://doi.org/10.1080/23743603.2016.1273647.
39. Deaton A, Cartwright N. Understanding and misunderstanding randomized controlled trials. *Soc Sci Med*. 2018;210:2–21. https://doi.org/10.1016/j.socscimed.2017.12.005.
40. VanderWeele TJ, Mathur MB, Chen Y. Outcome-wide longitudinal designs for causal inference: a new template for empirical studies. *Stat Sci*. In press.
41. Ryff CD, Singer B. Understanding healthy aging: key components and their integration. In: Bengston VL, Gans D, Pulney NM, Silverstein M, eds. *Handbook of Theories of Aging*. 2nd ed New York, NY: Springer Publishing Co, 2009:117–144.
42. Rowe JW, Kahn RL. Human aging: usual and successful. *Science*. 1987;237(4811):143–149. https://doi.org/10.1126/science.3299702.
43. Reich JW, Zautra AJ, Hall JS. *Handbook of Adult Resilience*. New York, NY: Guilford Press, 2010.
44. Aldwin CM, Successful Igarashi H. optimal, and resilient aging: A psychosocial perspective. In: Lichtenberg PA, Mast BT, Carpenter BD, Loebach Wetherell J, eds. *APA Handbooks in Psychology. APA Handbook of Clinical Geropsychology, Vol. 1. History and Status of the Field and Perspectives on Aging*. Washington, DC: American Psychological Association, 2015:331–359. https://doi.org/10.1037/14458-014.
45. Depp CA, Jeste DV. Definitions and predictors of successful aging: a comprehensive review of larger quantitative studies. *Am J Geriatr Psychiatry*. 2006;14(1):6–20. https://doi.org/10.1097/01.JGP.0000192501.03069.bc.
46. Smith J, Fisher G, Ryan L, Clarke P, House J, Weir D. *Psychosocial and lifestyle questionnaire 2006–2010: documentation report*. Ann Arbor, MI: Institute for Social Research: University of Michigan; February 2013. https://hrs.isr.umich.edu/sites/default/files/biblio/HRS2006-2010SAQdoc.pdf.
47. Fisher GG, Faul JD, Weir DR, Wallace RB. *HRS/AHEAD documentation report: documentation of chronic disease measures in the Health and Retirement Study (HRS/AHEAD)*. Ann Arbor, MI: Survey Research Center, University of Michigan; February 10, 2005. http://hrsonline.isr.umich.edu/sitedocs/userg/dr-009.pdf.
48. Jenkins KR, Ofstedal MB, Weir D. *HRS/AHEAD documentation report: documentation of health behaviors and risk factors measured in the Health and Retirement Study (HRS/AHEAD)*. Ann Arbor, MI: Survey Research Center, University of Michigan; February 2008. http://hrsonline.isr.umich.edu/sitedocs/userg/dr-010.pdf.
49. Dunn OJ. Multiple comparisons among means. *J Am Stat Assoc*. 1961;56(293):52–64. https://doi.org/10.1080/01621459.1961.10482090.
50. VanderWeele TJ, Mathur MB. Some desirable properties of the Bonferroni correction: is the Bonferroni correction really so bad? *Am J Epidemiol*. 2019;188(3):617–618. https://doi.org/10.1093/aje/kwy250.
51. VanderWeele TJ, Ding P. Sensitivity analysis in observational research: introducing the E-value. *Ann Intern Med*. 2017;167(4):268–274. https://doi.org/10.7326/M16-2607.
52. Sterne JA, White IR, Carlin JB, et al. Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. *BMJ*. 2009;338:b2393. https://doi.org/10.1136/bmj.b2393.
53. Moons KG, Donders RA, Stijnen T, Harrell FE Jr. Using the outcome for imputation of missing predictor values was preferred.

J Clin Epidemiol. 2006;59(10):1092–1101. https://doi.org/10.1016/j.jclinepi.2006.01.009.
54. Groenwold RH, Donders AR, Roes KCB, Harrell FE Jr, Moons KG. Dealing with missing outcome data in randomized trials and observational studies. *Am J Epidemiol.* 2012;175(3):210–217. https://doi.org/10.1093/aje/kwr302.
55. Asendorpf JB, van de Schoot R, Denissen JJ, Hutteman R. Reducing bias due to systematic attrition in longitudinal studies: the benefits of multiple imputation. *Int J Behav Dev.* 2014;38(5):453–460. https://doi.org/10.1177/0165025414542713.
56. Rawlings AM, Sang Y, Sharrett AR, et al. Multiple imputation of cognitive performance as a repeatedly measured outcome. *Eur J Epidemiol.* 2017;32(1):55–66. https://doi.org/10.1007/s10654-016-0197-8.
57. Cumming JJ, Goldstein H. Handling attrition and non-response in longitudinal data with an application to a study of Australian youth. *Longit Life Course Stud.* 2016;7(1):53–63. https://doi.org/10.14301/llcs.v7i1.342.
58. Weuve J, Proust-Lima C, Power MC, et al. Guidelines for reporting methodological challenges and evaluating potential bias in dementia research. *Alzheimers Dement.* 2015;11(9):1098–1109. https://doi.org/10.1016/j.jalz.2015.06.1885.
59. Harel O, Mitchell EM, Perkins NJ, et al. Multiple imputation for incomplete data in epidemiologic studies. *Am J Epidemiol.* 2018;187(3):576–584. https://doi.org/10.1093/aje/kwx349.
60. van Ginkel JR, Linting M, Rippe RCA, van der Voort A. Rebutting existing misconceptions about multiple imputation as a method for handling missing data. *J Pers Assess.* 2020;102(3):297–308. https://doi.org/10.1080/00223891.2018.1530680.
61. Van Willigen M. Differential benefits of volunteering across the life course. *J Gerontol B Psychol Sci Soc Sci.* 2000;55(5):S308–S318. https://doi.org/10.1093/geronb/55.5.S308.
62. Oman D. Does volunteering foster physical health and longevity? In: Post SG, editor. *Altruism and Health: Perspectives From Empirical Research*. New York, NY: Oxford University Press, 2007:15–32. https://doi.org/10.1093/acprof:oso/9780195182910.003.0003.
63. Wheeler JA, Gorey KM, Greenblatt B. The beneficial effects of volunteering for older volunteers and the people they serve: a meta-analysis. *Int J Aging Hum Dev.* 1998;47(1):69–79. https://doi.org/10.2190/VUMP-XCMF-FQYU-V0JH.
64. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. *PLoS Med.* 2010;7(7):e1000316. https://doi.org/10.1371/journal.pmed.1000316.
65. Kubzansky LD, Huffman JC, Boehm JK, et al. Positive psychological well-being and cardiovascular disease: JACC health promotion series. *J Am Coll Cardiol.* 2018;72(12):1382–1396. https://doi.org/10.1016/j.jacc.2018.07.042.
66. Kim ES, Delaney SW, Kubzansky LD. Sense of purpose in life and cardiovascular disease: underlying mechanisms and future directions. *Curr Cardiol Rep.* 2019;21(11):135. https://doi.org/10.1007/s11886-019-1222-9.
67. Danaei G, Tavakkoli M, Hernán MA. Bias in observational studies of prevalent users: lessons for comparative effectiveness research from a meta-analysis of statins. *Am J Epidemiol.* 2012;175(4):250–262. https://doi.org/10.1093/aje/kwr301.
68. Hernán MA. Counterpoint: epidemiology to guide decision-making: moving away from practice-free research. *Am J Epidemiol.* 2015;182(10):834–839. https://doi.org/10.1093/aje/kwv215.
69. VanderWeele TJ, Jackson JW, Li S. Causal inference and longitudinal data: a case study of religion and mental health. *Soc Psychiatry Psychiatr Epidemiol.* 2016;51(11):1457–1466. https://doi.org/10.1007/s00127-016-1281-9.