Research paper

The role of Hope in subsequent health and well-being for older adults: An outcome-wide longitudinal approach

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ABSTRACT

Hope is a topic widely discussed in the humanities and researched in the field of psychology. To explore the potential public health implications of hope for subsequent health and well-being outcomes, we prospectively examined the relation between baseline hope and a wide range of outcomes that included indicators of: physical health, health behaviors, and psychosocial well-being in older adults using an outcome-wide approach. Data from the Health and Retirement Study ($N = 12{,}998$, mean age $= 66$ years) were analyzed. Bonferroni correction was used to account for multiple testing. All models controlled for a wide array of factors including: sociodemographic characteristics, personality factors, and prior values of the exposure (hope) and all outcomes. A greater sense of hope was associated with: better physical health and health behavior outcomes on some indicators (e.g., reduced risk of all cause-mortality, fewer number of chronic conditions, lower risk of cancer, and fewer sleep problems), higher psychological well-being (e.g., increased positive affect, life satisfaction, and purpose in life), lower psychological distress, and better social well-being. A secondary analysis explored antecedents of hope. We identified several potentially modifiable factors that may lead to increased hope. These results may have important population-level implications for increasing hope and improving the physical, psychological, and social well-being of our growing older adult population.

Introduction

Discussions of hope and hopelessness are common in clinical care especially in the context of psychiatry. Indeed hopelessness is an item assessed for depression in DSM-V [1]. However the role of hope in shaping population health has received less attention and study. Hope is a concept deeply embedded in a variety of religious and philosophical traditions [2–4]. For example, Thomas Aquinas described hope as a passion that follows upon apprehension of a future good that is difficult, yet possible, to attain [5]. Distinct from discourse in the humanities, interest in hope emerged within the field of psychology in the mid-20th century, with initial conception about the construct as a unidimensional motivational force [6,7]. By the latter half of the 20th century, early proponents of positive psychology, most notably, Snyder, began conceptualizing hope as two interrelated cognitive dimensions: agency and pathways [8,9]. In Snyder's theory of hope, agency refers to determination and commitment to help one move in the direction of a goal, and pathways refer to people's perceived ability to reach their goals and formulate alternative plans when obstacles arise [7–9]. Said another way, this conception of hope might be understood to be a positive motivational state that enables people to persevere towards goals and pathways [8,10]. Thanks to the work of Snyder and others, diagnostic tools have been developed to measure hope and hopelessness, which have been used to evaluate associations with psychological and social well-being outcomes [11]. This body of research has found that hope has strong positive associations with a variety of psychosocial processes and outcomes such as emotional adjustment, positive affect, life satisfaction, sense of purpose, quality of life, and social support [12,13]. Conversely, low levels of hope – or hopelessness – have been positively associated with elevated risk of mental health problems such as anxiety, depression, and posttraumatic stress disorder [14,15]. Empirical and

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philosophical work suggests that hope is distinct from optimism [16,17], despite the continued conflation of the two terms in both popular and academic discussion. Some of the conflation may have emerged from the fact that agency and pathways are likely sources of hope, but also sources of optimism [8,9,18]. In returning to more classical understandings of hope, hope may be distinguished from optimism in that hope may be understood as a disposition towards having an attentional focus on the possibility that the future will be good, characteristically in the face of difficulty. Optimism, on the other hand, may be understood as a disposition towards having expectations that the future will be good (which may be with or without reasons).

While many empirical investigations on hope have focused on associations with psychological and social well-being outcomes, less attention has focused on the relationship between hope and health behaviors or physical health outcomes. Additionally, studies on hope often do not include older adults outside clinical settings, and instead often focus on younger populations and patient populations [12]. To help fill this knowledge gap, we used data from the Health and Retirement Study (HRS) [19], a large, prospective, and nationally representative sample of adults over age 50, to evaluate whether positive changes in hope are associated with better subsequent health and well-being. To answer this question, we used an outcome-wide analytic approach [20,21] which extensively controls for a wide range of covariates and also controls for the exposure (hope) in a prior wave; this allows researchers to remove the potential accumulating effects of hope on prior levels of health and well-being, and evaluate the effects of *change in* a sense of hope on subsequent health and well-being outcomes. We also conducted a secondary analysis to explore the potential antecedents of hope. Such evidence can inform further research, which in turn might foster public health and policy making efforts. Considerations of unmeasured confounding and reverse causation are of course a concern, but the goal of the present analysis is to, as best as possible, control for these and provide estimates of the outcomes we might expect to observe if levels of hope were intervened upon at the population level.

Method

Study population

We used data from the Health and Retirement Study (HRS), a nationally representative dataset of older adults aged >50 in the United States. In the first year that a robust set of psychosocial data were collected (2006), HRS staff visited a randomly-selected 50% of study participants for an enhanced face-to-face (EFTF) interview. After the interview, participants took a self-administered psychosocial questionnaire [22]. In 2008, the remaining 50% of participants were also assessed via both methods (EFTE and questionnaire); the response rate for the psychosocial questionnaire was 88% in 2006 and 84% in 2008 [22]. Similar data were obtained in subsequent waves. Our main exposure, hope, was assessed in the 2010/2012 waves, with subsequent health and well-being outcomes assessed four years later in the 2014/2016 waves and with covariate data (including prior hope) taken from the 2006/2008 wave. Further information about the HRS study and access to publicly available data can be found on the study websites (http://hrsonline.isr.umich.edu/ and https://hrs.isr.umich.edu/data-products). Given the use of de-identified, publicly available data, the study was exempted from IRB review at the Harvard T.H. Chan School of Public Health.

Measures

Hope

Within the HRS questionnaire, study respondents answered four questions that were derived from Everson et al. [23] and Beck et al. [24]. The questions asked: [1] "I feel it is impossible for me to reach the goals that I would like to strive for"; [2] "The future seems hopeless to me and I can't believe that things are changing for the better"; [3] "I don't expect to get what I really want"; and [4] "There's no use in really trying to get something I want because I probably won't get it." Response categories to these questions ranged from 1 (*strongly disagree*) to 6 (*strongly agree*). While negatively worded, items 1, 3 and 4 at least implicitly reference agency, item 1 references pathways, and item 2 references hope itself.

We reverse-coded the scale to construct a hope instead of hopelessness scale for three reasons. First, HRS is not a clinical or psychiatric population, and as a result, levels of "hopelessness" were relatively low. Even in the tertile with the highest hopelessness scores, the median response was to *slightly disagree* with all four items. Second, reverse wording of the questions strongly aligned with a widely accepted, empirical conceptualization of hope as a positive motivational state directing perseverance towards goals and pathways [8]. Third, the four items were not specifically constructed as a stand-alone scale but selected from other measures based on careful theorizing, allowing for a flexibility in how they were analyzed. As a result, we reverse-coded the four items and then averaged them together to construct our hope scale (e.g., It *is* possible for me to reach goals; the future seems *hopeful to me; I do* expect to get what I really want; There *is* use in trying, etc.) (alpha = 0.86 in 2006). To crudely examine potential dose-response patterns, we created tertiles based on the primary exposure (2010/2012) and the distribution of hope in the sample. The focus of the discussion will be on the comparison of the bottom and top tertiles, though evidence for trends will also be examined.

Outcomes

Using data from the 2014/2016 waves, 26 outcomes were assessed, including indicators of: physical health (all-cause mortality, number chronic conditions, diabetes, hypertension, stroke, cancer, heart disease, lung disease, arthritis, and overweight/obesity, chronic pain), health behaviors (binge drinking, smoking, physical activity, sleep problems), psychological well-being (positive affect, life satisfaction, optimism, purpose in life, mastery, hope), psychological distress (depression, depressive symptoms, negative affect), and social factors (loneliness, social integration). Hope was included as a "benchmark outcome" that facilitated the interpretation of effect sizes when evaluated against other outcomes. The rationale is that hopefulness at one time-point will be related to hopefulness subsequently, and an increase in hopefulness at one time-point will likely increase hopefulness at follow-up.

Further information about how each of these variables were assessed is available in the appendix and additional documentation about each measure can also be found in Smith et al. [22], Fisher et al. [25], and Jenkins et al. [26].

Covariates

We controlled for a wide range of covariates using data from the first waves of the study in 2006/2008. Covariates included age (continuous), sex (male/female), race/ethnicity (White, African-American, Hispanic, Other), marital status (married/not married), income (<$50,000, $50,000–$74,999, $75,000–$99,999, ≥$100,000), total wealth (based on quintiles of the score distribution in this sample), educational attainment (no degree, GED or high school diploma, ≥college degree), employment status (yes/no), health insurance (yes/no), geographic region (Northeast, Midwest, South, West), childhood abuse (yes/no), religious service attendance (none, <1× a week, ≥1× per week), and personality factors (openness, conscientiousness, extraversion, agreeableness, neuroticism). We also controlled for prior values of all outcome variables (listed above) in all our models to reduce the possibility of reverse causation. All covariates were controlled for in 2006/2008, prior to the primary hope exposure in 2010/2012 to help reduce concerns that we were controlling for mediators. We used this approach to covariate control [21] rather than other approaches to covariate selection, such as using causal diagrams, because the relationship between many of these covariates (e.g. income, employment,

depression, etc.) and hope is likely bi-directional and it is thus not plausible to posit a causal diagram with variables assessed contemporaneously. To allow for evaluation of *changes in degree of hope*, we controlled for hope in the first waves of the study (2006/2008), before our "baseline" assessment in 2010/2012, which further helped reduce reverse causation and potential unmeasured confounding [27].

Statistical analysis

We used an outcome-wide analytic approach [20,21], and ran a separate regression model for each outcome. Depending on the nature of the outcome variable, we ran one of three different models: [1] logistic regressions for binary outcomes with a prevalence <10%; [2] generalized linear models with a log link and Poisson distributions for binary outcomes with a prevalence ≥10%; and [3] linear regression models for continuous outcomes. With continuous variables, we standardized outcomes (mean = 0, standard deviation = 1) to allow effect sizes to be interpreted in terms of a standard deviation change in the outcome variable. All models fully adjusted for all covariates in the initial waves (2006/2008). Bonferroni correction was used to account for multiple testing [28].

As a secondary analysis, we explored potential antecedents (independent predictors) of a sense of hope. Using linear regression, we regressed wave 3 (2014/2016) hope on wave 2 (2010/2012) candidate antecedents (one at a time), controlling simultaneously for all of the same covariates that were used in the main outcome-wide analyses at wave 1 [21].

Multiple imputation

We imputed missing data for the exposure, covariates, and outcomes using an imputation by chained equations procedure, which involves generating 5 datasets. Compared to other methods of handling missing data, this approach has the advantage of flexibility [29–31].

Additional analyses

As a conservative approach to evaluate the robustness of evidence for the effects observed in this study to potential unmeasured confounding, we performed sensitivity analysis using *E*-values [32]. E-values assess the minimum strength of association that an unmeasured confounder would have to have on the risk ratio scale with *both* the exposure (hope) and a given outcome to explain away the association. For sensitivity to differential measurement error (e.g. those with higher hope subsequently reporting better outcomes even though nothing had changed), the estimates themselves correspond to bounds required for differential measurement error to reduce the estimates to the null [33]. We also re-analyzed all models using complete-case analysis and compared results. To enhance potential translation of results in a public health context, we transposed risk ratios in our main models into risk differences. For additional interpretive value, we also re-analyzed estimates of continuous outcomes in our main model without standardization. As another sensitivity analysis, we further re-analyzed the main models, but *removed* people who had history of a given condition at baseline (e.g., for the stroke analysis, we removed people who had stroke in the past). We conducted this analysis because controlling for past conditions does not always sufficiently control for other potential confounding that is introduced by health conditions (e.g., unmeasured health conditions that emerge from a primary illness); removing people with past history of a given condition is a more conservative approach that helps further reduce concerns about potential reverse causality. All analyses were conducted in Stata version 15.1 (StataCorp, College Station, Texas).

Results

At the initial waves of the study (2006/2008), the average age of respondents was 66 years old (SD = 9.9). Nearly two-thirds of study participants were women (59%). Just over half had a high school education (56%). The majority were White (74%), followed by Black (14%),

Hispanic (9%), and "Other (3%). In Table 1, we describe the distribution of covariates by tertiles of hope; the distribution of participant characteristics in the full analytic sample is shown in supplementary Table 1 (S1).

Over the 4-year follow-up period, participants in the highest (versus lowest) tertile of hope had a 16% lower risk of all-cause mortality (95% confidence interval [CI]: 0.71, 0.99). Participants with the highest (versus lowest) hope also had fewer chronic conditions ($\beta = -0.07$, 95% CI: −0.10,-0.03), 12% reduced probability of cancer (95% CI: 0.78, 0.99), and 11% reduced probability of chronic pain (95% CI: 0.81, 0.97; see Table 2). There was little evidence of association between hope and other physical health outcomes.

Among health behaviors, there was no evidence of association with binge drinking and smoking, but there was an 13% increased probability of frequent physical activity among participants with the highest levels of hope (95% CI: 1.05, 1.23), and a 12% reduced probability of sleep problems (95% CI: 0.81, 0.97) (Table 2).

Increased hope was also positively associated with *all* the indicators of psychological well-being, psychological distress, and social well-being (see Table 2). For example, those in the highest (verus lowest) tertile of hope subsequently reported higher life satisfaction and purpose, lower depression and loneliness, and better social integration.

Antecedents of Hope

Several characteristics were predictors of subsequent hope, including: physical health and behavior factors (e.g., physical activity, cancer, hypertension), social factors (e.g., frequency of contact with friends, loneliness, closeness with spouse, volunteering), and all dimensions of psychological well-being and distress. Effect size estimates were generally relatively modest (see Table 3).

Additional analyses

E-values suggested that several of the associations that we observed were at least somewhat robust to unmeasured confounding (see Table 4). For example, an unmeasured confounder associated with both hope and sleep problems by risk ratios of 1.53 each, above and beyond the large array of covariates already adjusted for, could suffice to explain away the association, but weaker confounding could not; to shift the CI to include the null, an unmeasured confounder associated with both hope and sleep problems by risk ratios of 1.21 each could do so but weaker confounding could not. Second, complete-case analysis yielded similar results to the results in the main analyses (Table S2). Table S3 reports risk difference estimates for the binary outcomes and helps clarify the absolute effect of increased hope on these outcomes, which may be useful in evaluating the potential public health impact of hope interventions. Table S4 presents unstandardized estimates for continuous outcomes in our main model. Finally, when reanalyzing the fully-adjusted models after removing anyone with history of a given condition at baseline, estimates were generally stronger (Table S5).

Discussion

Key findings of the outcome-wide analysis

In this nationally representative and prospective cohort study of older adults, we found positive associations between an increased sense of hope and indicators of physical health, health behaviors, and numerous dimensions of psychological and social well-being. While positive associations between hope and a variety of psychosocial outcomes are consistent with a large body of empirical research on hope [34], which is mostly cross-sectional, this study contributes to the literature and builds upon the pioneering work of others by using data from a large prospective cohort with four years of follow-up data. It also

Table 1
Characteristics of Participants at Baseline by Tertiles of Hope (N = 12,746)[a,b].

Participant Characteristics	Tertile 1 (N = 4594)				Tertile 2 (N = 4204)				Tertile 3 (N = 3966)			
	N	%	Mean	SD	N	%	Mean	SD	N	%	Mean	SD
Sociodemographic factors												
Age (yr; range: 47–97)			67.2	10.2			66.4	9.8			65.1	9.5
Female (%)	2608	56.8			2423	57.6			2480	62.5		
Race/Ethnicity (%)												
White	3235	70.4			3254	77.4			2963	74.8		
Black	666	14.5			532	12.7			611	15.4		
Hispanic	546	11.9			316	7.5			305	7.7		
Other	146	3.2			102	2.4			84	2.1		
Married (%)	2418	61.8			2503	68.8			2322	70.5		
Income (%)												
<$50,000	2668	68.5			1903	52.8			1445	44.1		
$50,000–$74,999	555	14.2			616	17.0			592	18.1		
$75,000–$99,999	284	7.3			423	11.7			380	11.6		
≥$100,000	390	10.0			678	18.7			863	26.3		
Total Wealth (%)												
1st Quintile	1083	27.8			599	16.6			461	14.1		
2nd Quintile	941	24.2			697	19.3			519	15.8		
3rd Quintile	765	19.6			767	21.2			634	19.3		
4th Quintile	637	16.4			795	22.0			737	22.5		
5th Quintile	471	12.1			762	21.1			929	28.3		
Education (%)												
< High School	1155	25.2			559	13.3			385	9.8		
High School	2626	57.3			2319	55.4			2011	50.9		
≥ College	802	17.5			1311	31.3			1554	39.3		
Employed (%)	1396	35.8			1560	43.1			1589	48.5		
Health Insurance (%)	3401	87.4			3153	87.2			2798	85.3		
Geographic Region (%)												
Northeast	623	15.7			545	14.9			474	14.2		
Midwest	1050	26.6			1055	28.8			853	25.6		
South	1600	40.5			1373	37.5			1307	39.2		
West	679	17.2			691	18.9			701	21.0		
Childhood Abuse (%)	275	7.8			210	6.3			197	6.5		
Physical Health												
Diabetes (%)	863	22.2			607	16.8			423	12.9		
Hypertension (%)	2271	58.4			1907	52.7			1592	48.6		
Stroke (%)	293	7.5			186	5.1			151	4.6		
Cancer (%)	533	13.7			482	13.3			438	13.4		
Heart Disease (%)	950	24.4			714	19.8			518	15.8		
Lung Disease (%)	425	10.9			242	6.7			162	5.0		
Arthritis (%)	2439	62.6			2101	58.1			1661	50.7		
Overweight/Obesity (%)	2904	75.6			2553	71.3			2235	69.0		
Chronic Pain (%)	1608	41.3			1150	31.8			831	25.3		
Health Behaviors												
Binge Drinking (%)	395	12.5			399	13.6			389	14.6		
Smoking (%)	659	17.1			397	11.0			292	9.0		
Frequent Physical Activity (%)	2740	70.4			2817	77.9			2715	82.8		
Sleep Problems (%)	1060	47.7			797	39.9			576	33.2		
Religious Service Attendance (%)												
Never	1069	27.5			808	22.4			698	21.3		
<1×/week	1306	33.5			1169	32.3			1030	31.4		
≥1×/week	1519	39.0			1639	45.3			1550	47.3		
Psychological Well-Being												
Positive Affect (range: 1–5)			3.3	0.8			3.7	0.6			3.9	0.6
Life Satisfaction (range: 1–7)			4.6	1.5			5.2	1.3			5.6	1.3
Optimism (range: 1–6)			4	0.9			4.6	0.8			5.1	0.8
Purpose in Life (range: 1–6)			4.2	0.9			4.7	0.8			5.1	0.8
Mastery (range: 1–6)			4.5	1.1			4.9	1			5.2	1
Hope (range: 1–6)												
Psychological Distress												
Depression (%)	807	21.1			301	8.5			197	6.1		
Depressive Symptoms (range: 0–8)			1.9	2.2			1.1	1.6			0.8	1.4
Hopelessness (range: 1–6)			3.1	1.3			2.1	1			1.5	0.8
Negative Affect (range: 1–5)			1.9	0.7			1.6	0.5			1.4	0.4
Social Factors												
Loneliness (range: 1–3)			1.7	0.6			1.4	0.5			1.3	0.4
Social Integration (range: 0–5)			2.7	1.2			3	1.2			3.2	1.1
Personality												
Openness (range: 1–4)			2.8	0.6			3	0.5			3.2	0.5
Conscientiousness (range: 1–4)			3.3	0.5			3.4	0.4			3.5	0.4
Extraversion (range: 1–4)			3.1	0.6			3.2	0.5			3.4	0.5
Agreeableness (range: 1–4)			3.5	0.5			3.5	0.5			3.7	0.4
Neuroticism (range: 1–4)			2.2	0.6			2.0	0.6			1.8	0.6

[a] This table was created based on non-imputed data.
[b] All of these variables were used as covariates, and assessed in the wave prior (2006/2008) to the exposure wave (2010/2012).

Table 2
Hope and Subsequent Health and Well-being (Health and Retirement Study [HRS]: N =12,998)[a,b,c]

	Hope			p-trend
	Tertile 1 (n = 4,704) (Reference)	Tertile 2 (n = 4,282) RR/OR/β (95% CI)	Tertile 3 (n = 4,012) RR/OR/β (95% CI)	
Physical Health				
All-cause mortality	1.00	0.89 (0.78, 1.02)	0.84 (0.71, 0.99)*	0.02
Number of chronic conditions	0.00	-0.04 (-0.07, -0.01)***	-0.07 (-0.10, -0.03)***	<0.001
Diabetes	1.00	1.00 (0.92, 1.09)	0.97 (0.87, 1.07)	0.61
Hypertension	1.00	0.99 (0.94, 1.05)	0.99 (0.93, 1.06)	0.75
Stroke	1.00	0.90 (0.78, 1.03)	0.90 (0.77, 1.05)	0.10
Cancer	1.00	0.93 (0.84, 1.04)	0.88 (0.78, 0.99)*	0.04
Heart disease	1.00	0.96 (0.88, 1.03)	0.93 (0.84, 1.03)	0.12
Lung disease	1.00	0.91 (0.81, 1.03)	0.90 (0.78, 1.04)	0.09
Arthritis	1.00	0.99 (0.94, 1.05)	0.97 (0.91, 1.04)	0.47
Overweight/obesity	1.00	1.02 (0.96, 1.07)	1.01 (0.94, 1.07)	0.76
Chronic pain	1.00	0.94 (0.87, 1.01)	0.89 (0.81, 0.97)*	0.01
Health Behaviors				
Binge drinking	1.00	1.10 (0.89, 1.34)	1.00 (0.76, 1.32)	0.84
Current cigarette smoking	1.00	0.89 (0.70, 1.14)	1.01 (0.78, 1.32)	0.79
Frequent physical activity	1.00	1.11 (1.03, 1.19)**	1.13 (1.05, 1.23)**	0.002
Sleep problems	1.00	0.95 (0.88, 1.02)	0.88 (0.81, 0.97)*	0.01
Psychological Well-being				
Positive affect	0.00	0.22 (0.17, 0.26)***	0.38 (0.32, 0.44)***	<0.001
Life satisfaction	0.00	0.15 (0.10, 0.20)***	0.28 (0.22, 0.35)***	<0.001
Optimism	0.00	0.27 (0.22, 0.32)***	0.50 (0.45, 0.55)***	<0.001
Purpose in life	0.00	0.17 (0.13, 0.21)***	0.34 (0.29, 0.39)***	<0.001
Mastery	0.00	0.19 (0.14, 0.24)***	0.35 (0.29, 0.40)***	<0.001
Hope	0.00	0.41 (0.37, 0.46)***	0.66 (0.61, 0.70)***	<0.001
Psychological Distress				
Depression	1.00	0.74 (0.65, 0.85)***	0.57 (0.47, 0.69)***	<0.001
Depressive symptoms	0.00	-0.18 (-0.23, -0.14)***	-0.23 (-0.29, -0.17)***	<0.001
Negative Affect	0.00	-0.11 (-0.16, -0.06)***	-0.23 (-0.29, -0.18)***	<0.001
Social Factors				
Loneliness	0.00	-0.18 (-0.22, -0.13)***	-0.28 (-0.33, -0.24)***	<0.001
Social integration	0.00	0.04 (-0.01, 0.11)	0.06 (0.01, 0.12)*	0.03

Abbreviations: CI, confidence interval; OR, odds ratio; RR, risk ratio.
*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=0.05/26 outcomes= p<0.002)

[a] The analytic sample was restricted to those who had participated in the baseline wave (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, income, total wealth, level of education, employment status, health insurance, geographic region), prior childhood abuse, prior religious service attendance, prior values of the outcome variables (diabetes, hypertension, stroke, cancer, heart disease, lung disease, arthritis, overweight/obesity, chronic pain, binge drinking, current smoking status, physical activity, sleep problems, positive affect, life satisfaction, optimism, purpose in life, mastery, depressive symptoms, negative affect, loneliness, social integration), personality factors (openness, conscientiousness, extraversion, agreeableness, neuroticism) and the prior value of the exposure. These variables were controlled for in the wave prior to the exposure assessment (in 2006 or 2008).

[b] We used an outcome-wide analytic approach, and ran a separate model for each outcome. We also ran a different type of model depending on the nature of the outcome: 1) for each binary outcome with a prevalence of ≥10%, we ran a generalized linear model with a log link and Poisson distribution to estimate a RR; 2) for each binary outcome with a prevalence of <10%, we ran a logistic regression model to estimate an OR; and 3) for each continuous outcome, we ran a linear regression model to estimate a β. If the reference value is "1," the effect estimate is OR or RR; if the reference value is "0," the effect estimate is β.

[c] All continuous outcomes were standardized (mean=0, standard deviation=1), and β was the standardized effect size.

extends prior work by extensively controlling for confounding and addressing reverse causation in more rigorous ways. Further, it evaluated a range of health behaviors and physical health outcomes, factors that have been understudied in the hope literature.

Among the psychological well-being, psychological distress, and social factors outcomes examined in this study (n = 11), the positive associations we observed align with prior studies that point to the potentially positive impact of hope on psychosocial well-being [7,14,35–37]. For the remaining physical health and health behavior outcomes included in the analysis (n = 15), associations with hope were mixed, with evidence for associations with a some outcomes (e.g., reduced all-cause mortality, reduced number of chronic conditions) but less strong or no association with others (e.g., stroke, diabetes, hypertension). These latter results are consistent with some cross-sectional studies that have not always observed clear associations between hope and physical health outcomes [38]. Our observations around the hope-mortality association, are, however, supported by others. For example, one study reported an increase in all-cause and cause-specific mortality among middle-aged men with elevated hopelessness [23].

Study participants with high levels hope also had a fewer number of chronic conditions. Existing research on hope and chronic conditions tends to focus on evaluating the role of hope among people already diagnosed with a particular condition, for example, hope as an antecedent of stress-buffering among people living with multiplesclerosis [39]. Additionally, many studies have explored the relation between hope and cancer, but they often focused on the role of hope *after* a diagnosis, for example with regard to positive adjustment and coping strategies [40]. Our analysis extends the literature by using data from a community sample and examining the relationship between changing levels of hope and self-reported cancer diagnosis. Even after extensive confounding control, those with the highest levels of hope had 12% reduced probability of cancer over follow-up. This result converges with the work of others who also observed that even moderate hopelessness was associated with incident cancer [23]. Such findings should be interpreted with caution in light of this study's limitations, and more research on this topic is needed. Our analysis also highlights associations between increased hope and reduced probability of experiencing chronic pain and sleep problems. Other experimental and cross-sectional studies have observed similar associations between hope and reduced pain and less fatigue [41,42]. The longitudinal nature of the present study strengthens the existing evidence in this area.

Table 3
Candidate Predictors of Hope (N = 13,771)[a,b].

Candidate Predictor	Standardized Regression Coefficient (β)	95% CI
Health behaviors		
Physical Activity	0.06	0.03, 0.09***
Smoking	0.03	−0.84, 0.91
Overweight / Obese	0.02	−0.03,0.07
Binge Drinking	0.04	−0.20, 0.29
Physical Health		
Heart Disease	−0.09	−0.22, 0.05
Stroke	−0.16	−0.58, 0.26
Cancer	−0.14	−0.20, −0.08***
Arthritis	−0.06	−0.11, 0.00*
Hypertension	−0.10	−0.18, −0.04**
Diabetes	−0.01	−0.13, 0.11
Lung Disease	−0.14	−0.57, 0.30
Chronic Pain	−0.04	−0.09, 0.02
Social factors		
Live with Spouse	−0.01	−0.69, 0.66
Frequency of Contact with Children		
≤Every Few Months	Reference	Reference
1-2×/Month	0.07	−0.00, 0.13*
1-2×/Week	0.10	−0.12, 0.31
≥3×/Week	0.10	−0.21, 0.40
Frequency of Contact with Other Family		
≤Every Few Months	Reference	Reference
1-2×/Month	0.08	−0.10, 0.25
1-2×/Week	0.06	−0.07, 0.19
≥3×/Week	0.05	−0.29, 0.40
Frequency of Contact with Friends		
≤Every Few Months	Reference	Reference
1-2×/Month	0.12	0.06, 0.19**
1-2×/Week	0.11	−0.03, 0.20*
≥3×/Week	0.14	0.03, 0.25*
Loneliness	−0.11	−0.13, −0.10***
Closeness with Spouse	0.06	0.05, 0.08***
Number of Close Children	0.01	−0.02, 0.03
Number of Closeness Other Family	−0.00	−0.01, 0.01
Number of Close Friends	0.01	−0.03, 0.05
Positive Social Support from Spouse	0.10	0.06, 0.14**
Positive Social Support from Children	0.04	−0.06, 0.15
Positive Social Support from Other Family	0.03	0.01, 0.06*
Positive Social Support from Friends	0.03	−0.19, 0.24
Social Strain from Spouse	−0.14	−0.21, −0.08**
Social Strain from Children	−0.05	−0.07, −0.04***
Social Strain from Other Family	−0.03	−0.07, 0.02
Social Strain from Friends	−0.01	−0.09, 0.08
Religious Service Attendance		
Not at All	Reference	Reference
<1×/week	0.04	−0.28, 0.37
≥1×/week	0.07	−0.10, 0.24
Volunteering		
0 h	Reference	Reference
0–49 h	0.04	−0.02, 0.11
50–99 h	0.03	−0.03, 0.10
100–199 h	0.11	0.05, 0.16***
≥200 h	0.09	0.02, 0.16*
Psychological Well-being		
Life Satisfaction	0.12	0.10, 0.14***
Positive Affect	0.18	0.16, 0.19***
Purpose in Life	0.20	0.16, 0.24***
Optimism	0.25	0.24, 0.27***
Mastery	0.11	0.10, 0.13***
Psychological Distress		
Depressive Symptoms	−0.08	−0.10, −0.05***
Negative Affect	−0.14	−0.18, −0.11**
Anxiety	−0.14	−0.15, −0.12***

Table 3 (continued)

Candidate Predictor	Standardized Regression Coefficient (β)	95% CI
Work		
In Labor Force	0.05	−0.01, 0.11

*P < .05 before Bonferroni correction; **P < .01 before Bonferroni correction; ***P < .05 after Bonferroni correction (the P value cutoff for Bonferroni correction is P = .05/55 predictors = P < .0009).

[a] The analytic sample was restricted to those who had participated in the baseline wave (2006 or 2008). Multiple imputation was performed to impute missing data on the exposure, covariates, and outcomes. Candidate antecedents were assessed, one at a time, in wave 2 (2010/2012), and the outcome (hope) was assessed in wave 3 (2014/2016). The following covariates (including prior hope) were controlled for at wave 1 (2006/2008): sociodemographic characteristics (age, sex, race/ethnicity, marital status, income, total wealth, level of education, employment status, health insurance, geographic region), childhood abuse, and all of the predictor variables, including: health behaviors (physical activity, smoking, overweight/obese, binge drinking), physical health (heart disease, stroke, cancer, arthritis, hypertension, diabetes, lung disease, chronic pain), social factors (live with spouse, frequency of contact with children, frequency of contact with other family, frequency of contact with friends, loneliness, closeness with spouse, closeness with children, closeness with other family, closeness with friends, positive social support from spouse, positive social support from children, positive social support from friends, positive social support from other family, social strain from spouse, social strain from children, social strain from other family, social strain from friends, religious service attendance, volunteering), psychological well-being factors (life satisfaction, positive affect, purpose in life, optimism, mastery), psychological distress (depressive symptoms, negative affect, anxiety), work (in labor force).

[b] The outcome hope and all continuous candidate antecedents were standardized (mean = 0; standard deviation = 1), and β was the standardized effect size.

Key findings of the secondary analysis: Antecedents of hope

This study also examined potential antecedents of hope. In the analysis we controlled for a wide range of exposures at baseline, allowing us to more closely approximate the potential impact of *change* in exposures on the outcome (hope). This secondary analysis suggested a number of potentially modifiable factors that might impact hope. Taken together, the results of the two analyses suggest a bidirectional relationship between hope and several health and well-being factors. In other words, after adjusting for all prior values of all exposures and outcomes, features of a flourishing life—life satisfaction, physical and mental health, purpose, and elements of social relationships [43]–predict increased levels of hope, while increased levels of hope are also associated with many subsequently improved indicators of health and psychosocial well-being.

Limitations and strengths

One limitation of the study is the self-report nature of HRS data. To further strengthen the findings, future studies should re-evaluate associations between hope with objectively assessed physical health, health behavior, and mental health outcomes. Second, while four years of follow-up data allowed for longitudinal analysis, it may not have been long enough to assess the influence of hope on chronic diseases, which slowly worsen over time. Future studies could evaluate hope associations with later waves of HRS data or other datasets that have longer follow-up times. Likewise, a 4-year follow-up limits the interpretation of the analysis on the antecedents of hope. Hope may be shaped over the lifecourse. Four years may not be adequate to assess this. For example, effect estimates between religious service attendance and hope were relatively small. However, if the effect of religious service attendance accumulates over the lifecourse or is especially pronounced earlier in life, an analysis such as ours could not detect this. Third, our study only includes participants over age 50, limiting the generalizability of these results. Fourth, there might have been residual counfounding due to categorization of continuous variables as well as confounding by unmeasured factors. To reduce such concerns, we

Table 4
Robustness to Unmeasured Confounding (*E*-Values) for the Associations Between Hope (3rd Tertile vs. 1st Tertile) and Subsequent Health and Well-Being (*N* = 12,998)[a].

	Effect Estimate[b]	Confidence Interval Limit[c]
Physical Health		
All-cause mortality	1.67	1.11
Number of chronic conditions	1.32	1.21
Diabetes	1.21	1.00
Hypertension	1.11	1.00
Stroke	1.46	1.00
Cancer	1.53	1.11
Heart disease	1.36	1.00
Lung disease	1.46	1.00
Arthritis	1.21	1.00
Overweight/obesity	1.11	1.00
Chronic pain	1.50	1.21
Health Behaviors		
Binge drinking	1.00	1.00
Current cigarette smoking	1.11	1.00
Frequent physical activity	1.51	1.28
Sleep problems	1.53	1.21
Psychological Well-being		
Positive affect	2.18	2.02
Life satisfaction	1.91	1.75
Optimism	2.53	2.38
Purpose in life	2.06	1.90
Mastery	2.08	1.94
Hope	3.04	2.89
Psychological Distress		
Depression	2.90	2.26
Depressive symptoms	1.77	1.62
Negative Affect	1.78	1.00
Social Factors		
Loneliness	1.92	1.79
Social integration	1.31	1.12

[a] See VanderWeele and Ding for the formula for calculating *E*-values.
[b] 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.
[c] The E-values for the limit of the 95% confidence interval (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 confidence interval to include the null value, conditional on the measured covariates.

used prospective data, extensive covariate control, and reported *E*-values to assess the robustness of our observed results to unmeasured confounding [32,44]. The E-values for the estimates suggested that several of the observed associations were moderately robust to potential unmeasured confounding, especially for the psychosocial outcomes. For the physical health outcomes, while the E-values for estimates sometimes indicated moderate robustness, the E-values for the confidence intervals were more modest. Thus, possibly, a combination of unmeasured confounding and statistical uncertainty could explain away these results. Conversely, however, confounding can also give rise to biases towards the null and it is thus possible that some of the effects are larger than the estimates we observed in this study. Finally, the outcome-wide approach increases the possibility of model misspecificaiton given the number of outcomes that are modeled. However, the outcome-wide approach also has several advantages that help offset this limitation. For example, in contrast with analyses that focus on a single outcome, the outcome-wide approach minimizes the "investigator degrees of freedom" because a robust and uniform range of covariates were used to adjust for all outcomes and also structurally allows for publication of strong associations, as well as estimates that are close to null, and null. This, in turn, allows for a more rapid accumulation of results that might eventually be used for meta-analysis, which in turn can further advance our collective knowledge [21]. Further strengths of this study include the use of a large, diverse, prospective, and nationally representative sample of U.S. adults over age 50. Further, by adjusting

for prior values of exposures, covariates, and outcomes in our primary analysis, we evaluated incident exposure (the change in level of hope) vs. prevalent exposure (the existence of hope). These techniques ultimately provide stronger evidence for causality [27,45,46]. Likewise, in our secondary analysis, extensive statistical control allowed us to assess the potential impact of change in a variety of potential antecedents of hope. Finally, by using a meta-science perspective, we examined multiple associations simultaneously, allowing us to more easily report on strong associations as well, as weak, and null associations [20,21].

Implications and future research

The later stages of life are often defined by loss: the loss of health, loved ones, social support networks, independence, and (eventually) loss of life itself. Similarly, most investigations around hopelessness examine a negative state that is most often addressed curatively, through, for example, psychotherapy or other forms of therapy. Hope may serve as an important antidote to loss and these analyses may thus have important population health implications. First, our results suggest that standard public health promotion activities, which often focus solely on physical health, might be expanded to include a wider range of factors that may lead to gains in hope. For example, alongside community-based health and nutrition programs aimed at reducing chronic conditions like hypertension, programs that help strengthen marital relations (e.g., closeness with a spouse), provide opportunities to volunteer, help lower anxiety, or increase connection with friends may potentially increase levels of hope, which in turn, may improve levels of health and well-being in a variety of domains. Second, a select number of hope-based interventions have been successfully applied in a number of contexts [47], for example hope-based couples counseling [48] and hope-based interventions that improve pain tolerance and pain perception [49,50]. We suggest that lessons from these programs might be built upon and expanded for broader application at the population-level.

Developing and testing hope-based health and well-being interventions also merit further study. While further research is necessary, hope interventions may also help address the recent increases in "deaths of despair" [51]. Conceptualization and measurement of hope also deserves further attention and might be refined for use in population-wide assessment. While this study and numerous others use the conceptualization of hope as two inter-related cognitive dimensions of agency and pathways, there are many who question this framing, particularly the emphasis on agency, which seems to ignore the possibility that some hoped-for outcomes are beyond one's control. Among other conceptual issues to be considered is the role of uncertain-yet-possible outcomes in relationship to hope [17], and the role of existential meaning in the formation and maintenance of hope [2,5,52,53].

Conclusion

This study documented numerous positive associations between hope and subsequent health and well-being outcomes. While associations between hope and psychological and social well-being were consistently positive, the study also suggested associations with some physical health and health behavior outcomes, including evidence for a reduced probability of all-cause mortality. The secondary analysis also identified several antecedents for hope, highlighting several potential areas that public health researchers and practitioners might focus their efforts on when potentially trying to increase levels of hope, and by possible extension, levels of health and well-being.

While the results of this study have important implications for older adult populations, the broad alignment of our results with previous research that has been focused on younger populations indicates that these findings may have population-level implications and indicate a need for further inquiry. Although "hope" may be viewed as a concept beyond the purview of some public health practitioners, this study

highlights associations between hope and a variety of physical, mental, and social well-being outcomes, which suggest that hope is an important area of future inquiry and practice in public health.

Acknowledgements

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloepi.2020.100018.

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