Smoking and Physical Activity Explain the Increased Mortality Risk Following Marital Separation and Divorce: Evidence From the English Longitudinal Study of Ageing

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Abstract

Background Marital separation and divorce are associated with an increased risk of early mortality, but the specific biobehavioral pathways that explain this association remain largely unknown.

Purpose This study sought to identify the putative psychological, behavioral, and biomarker variables that can help explain the association of being separated or divorced and increased risk for early mortality.

Methods Using data from the English Longitudinal Study of Ageing, a representative community sample of aging adults ($N = 5,786$), we examined the association of marital status and life satisfaction, health behaviors measured 2 years later, biomarkers measured 4 years later, and mortality outcomes from the subsequent 4 years.

Results Consistent with prior literature, older adults who were separated/divorced evidenced greater risk of mortality relative to those in intact marriages over the study period, $OR = 1.46$, 95% CI [1.15, 1.86]. Marital status was associated with lower levels of life satisfaction, $\beta = -0.22$ [-0.25, -0.19] and greater likelihood of smoking 2 years later $\beta = 0.17$ [0.13, 0.21]. Lower life satisfaction predicted less frequent physical activity 2 years later, $\beta = 0.07$ [0.03, 0.10]. Smoking, but not physical activity, predicted poorer lung functioning 2 years later, $\beta = -0.43$ [-0.51, -0.35], and poorer lung function predicted increased likelihood of mortality over the following 4 years, $\beta = -0.15$ [-0.27, -0.03]. There was a significant total indirect effect of marital status on mortality through these psychological, behavioral, and

biomarker variables, $\beta = 0.03$ [0.01, 0.05], which fully explained this mortality risk.

Conclusions For separated/divorced adults, differences in life satisfaction predict health behaviors associated with poorer long-term lung function, and these intermediate variables help explain the association between marital dissolution and increased risk of earlier mortality.

Keywords Marital status • Mortality • Lung function • Life satisfaction • Smoking • Physical activity

Marital dissolution is a stressful but common life event, with approximately 45% of marriages ending in marital separation or divorce [1]. Marital separation and divorce are linked to a range of poor health outcomes, including increased risk for early death. Meta-analytic studies, involving total sample sizes from 6.5 to 600 million people [2, 3], indicate that being separated or divorced, relative to being married, is associated with a 23–30% increased risk for earlier all-cause mortality. This effect is generally larger for men than women, though this difference appears to be less meaningful at older ages [2, 3]. The mechanistic explanations for this mortality effect, however, remain poorly understood [4]. One strategy for studying potential mechanisms of action is to work backward from clinical endpoints through the relevant psychological, behavioral, and biomarker variables of interest to identify biologically plausible pathways that may explain health risk over time [5]. The current report implements this approach with a primary aim of identifying the psychological, health behavior, and biomarker variables that may explain the association between marital status and risk for early mortality. Figure 1 displays the basic pathways of interest and the integrative model guiding this study.

The starting point for our analysis is the study of health behaviors. Health behaviors represent a critical

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Fig. 1. Organization of current study. The first model illustrates the previously established finding connecting marital status and mortality status. The next model illustrates the conceptual mediation model, including the latent constructs that might explain the association of divorce and early death. The final model uses candidate variables drawn from the English Longitudinal Study of Ageing (ELSA) study matching the conceptual model's constructs of interest to test a statistical mediation model.

explanatory pathway that may give rise to ill health for separated and divorced adults. Health behaviors unfold in social contexts and are often controlled or regulated within close relationships [6, 7]. When a spouse makes a positive health change in his or her smoking status, weight, or physical activity level, it predicts positive change for his or her partner's health behavior [8]. Spousal effects on health behaviors are disrupted for people whose marriages have ended, and this change could then have implications for long-term health, depending on the impact spouses exert over their partners' health behaviors. For example, divorced adults report greater tobacco use and lower physical activity levels than their married counterparts [9]. Given that health behaviors are linked to risk for early mortality [10, 11] and are often organized in a relational context [6, 8], tobacco use and physical activity levels may play an important intermediate role in the association between marital status and mortality risk. In contrast, it is possible that leaving a high-conflict relationship with someone who has lower physical activity could result in positive changes in physical activity level after marital dissolution.

What factors may explain differences in health-compromising behaviors by marital status? We argue that a fully integrative model linking marital status to distal health outcomes must examine individual differences in psychological resources [12]. Separated and divorced adults typically report losing a key source of social support [13] and have lower life satisfaction levels compared with married adults [14]. This association is partially

explained by preexisting differences between people that eventually become divorced and those who do not, but longitudinal studies also find that there are losses in life satisfaction following divorce that maintain over the long term [15]. Fewer psychological resources, such as life satisfaction, can hinder effortful inhibition, in which people promote long-term goals over short terms impulses [16]. In a health context, a reduction in effortful inhibition can result in poorer long-term health behavior choices when faced with impulses toward negative health behaviors in the short term [17]. Lower levels of life satisfaction may inhibit the ability to avoid harmful health behaviors and help explain increased tobacco use and lower levels of physical activity among divorced people [9]. In the current report, we examine whether being separated or divorced is associated with lower life satisfaction among older adults, and whether life satisfaction can explain the association between marital status and poorer health behaviors.

Looking further downstream, differences in health behaviors can also predict differences in biomarkers that promote pathophysiology and serve as clinical indicators of increased risk for early mortality. Systemic inflammation and respiratory functioning are emerging candidate pathways that may be relevant to understanding how health behaviors, including smoking or physical activity, predict increased risk for early death. Both tobacco use and less physical activity are associated with decreased respiratory function [18, 19] and increased systemic inflammation, as assessed by C-reactive protein

(CRP) [20, 21]. These biomarkers are also strong, unique predictors of early death among aging adults [22, 23], making them ideal candidate biomarkers to include in a mechanistic chain from marital dissolution through health behaviors to mortality risk.

The Present Study

Using a longitudinal, nationally representative sample of aging adults ($N = 5,786$), the current report examined the association between marital dissolution and early mortality by testing a plausible longitudinal path analysis through which this effect may unfold. As noted above, the conceptual and statistical models guiding this work are presented in Fig. 1. First, we sought to replicate the direct association between marital separation/divorce and increased mortality risk. Working backward from mortality (cf. [5]), we then modeled additional intervening variables, including CRP levels and lung functioning as proximal biomarkers, smoking, and physical activity as key health behaviors, and life satisfaction as a psychological resource influencing these behaviors. Formally, we hypothesized that marital status—specifically being separated/divorced compared with being married—would predict lower life satisfaction, and that lower life satisfaction among separated/divorced adults would predict greater likelihood of smoking and lower levels of physical activity 2 years later. We also hypothesized that smoking status and less physical activity would in turn predict higher CRP levels and poorer lung function an additional 2 years later, which would predict increased risk for early death over the subsequent 4 years. To be clear from the outset, this study is not about the process of marital dissolution and concomitant effects on health. Instead, we began with aging adults who were separated/divorced, then examined differences between these participants and married adults in life satisfaction, health behaviors, biomarkers, and mortality across four waves of the English Longitudinal Study of Aging (ELSA). Although it would be informative to study the transition out of marriage as well, the approach we use here has the benefit of studying a series of intermediate variables that may account for the well-known association between divorce and early death.

Method

Data Sources

The ELSA currently has seven waves of data collected every 2 years beginning in 2002 [24]. These waves were supplemented by home visits by a nurse every 4 years (Waves 2, 4, and 6), during which a variety of biomarkers were collected. ELSA was designed to collect information on a representative sample of English people over the age of 50.

Details regarding the selection, eligibility, and recruitment of participants, participant demographics, and study methodology are reported in more detail in the ELSA Technical Report and User Guide [24] and ELSA Cohort Profile [25].

For the present study, we selected participants who participated in the Wave 2 core assessment and reported they were either married ($n = 5,233$) or separated/divorced ($n = 997$). Wave 2 was used as the first time point (Time 1 [T1]) for the study, with subsequent waves representing the following time points (e.g., T2, T3). For our initial model, we included all participants with Wave 2 marital status, age, and gender data, as well as subsequent mortality data collected following Wave 2 through Wave 6 ($N = 6,003$). For the path analysis models, we also excluded participants that passed away before the Wave 4 assessment and were alive to respond to the Waves 2–4 variables of interest. These participants were excluded, as including them while also using maximum likelihood estimation models would have resulted in estimating data for deceased participants after their death. Figure 2 outlines the process of inclusion and exclusion of participants. Demographic variables for the final sample ($N = 5,786$; $n = 926$ separated/divorced, 16% of total sample) are presented in Table 1. The average age of participants at the first assessment was 63.14 years; 53.9% were female, and the sample was primarily White (97.1%).

Fig. 2. Flowchart outlining the selection of the participants for the three main models of interest. In addition, any models including C-reactive protein were reduced from $n = 5,786$ to $n = 5,288$ due to excluding participants with scores greater than 10 mg/L. ELSA English Longitudinal Study of Ageing.

Table 1 Correlations and descriptive statistics for study variables used in Models 1, 2, and 3

	1	2	3	4	5	6	7	8	9	10
Marital status (1)	1.00									
T1 life satisfaction (2)	-.25	1.00								
T2 smoking status (3)	.23	-.14	1.00							
T2 physical activity (4)	-.04	.16	-.15	1.00						
T2 lung function (5)	-.09	.03	-.31	.18	1.00					
Mortality status (6)	-.04	-.03	.14	-.29	-.29	1.00				
Age (7)	-.09	.09	-.19	-.22	-.23	.49	1.00			
Gender (8)	.12	-.01	.01	-.10	-.21	-.20	-.16	1.00		
Self-reported health (9)	.07	-.31	.20	-.37	-.18	.27	.13	-.02	1.00	
Household wealth (10)	-.09	.08	-.43	.11	.06	-.09	-.02	-.02	-.10	1.00
Mean		26.73		1.88	375.68		63.14		2.71	66.0
SD		5.98		0.78	44.98		8.99		1.10	188.0
Percentages (%)	84.1		13.3			7.0		54.0		
	Married		Smoke			Deceased		Women		

All means and SDs were calculated using full information maximum likelihood estimation. Marital status, 0 = married and remarried, 1 = divorced; mortality, 0 = living, 1 = dead; gender, 1 = men, 2 = women. Mean wealth is listed in thousands.

Measures

Demographic covariates

Demographic variables included self-reported age and gender.

Marital status Marital status was assessed using participants' self-report at the study's start. As noted earlier in the text, separated/divorced adults were combined into a single group and coded as either married (0) or separated/divorced (1). It is possible participants' marital statuses changed after the start of the study, however, excluding participants whose marital status changed during the study ($n = 679$), did not change the substantive results of the study.

Wealth Participants self-reported their total gross household financial wealth across a variety of domains, which were then combined into a single variable assessing their gross wealth in British pound sterling [24].

Mortality Mortality was assessed using ELSA's end-of-life data, which tracked participant mortality over time. Participants were coded as either living (0) or deceased (1). In total, there were 766 deaths from Waves 2–6 (123 separated/divorced, 16.1% of deaths), with 413 deaths Waves 4–6 (54 separated/divorced, 13.1% of deaths).

Physical health

Physical health was assessed using participants' response to a five-point Likert-type scale asking "How is your health in general? Would you say it was..." with responses ranging from "poor" to "excellent." Scores were coded so that higher scores denoted poorer self-perceived physical

health. Self-perceived health is generally a valid measure of physical health among aging adults, showing both convergent validity [26] and predictive validity related to future health problems and mortality [27].

Life satisfaction

Life satisfaction was assessed using the Satisfaction with Life Scale [28], a reliable and valid scale made up of five items. Responses were rated on a Likert-type scale from 1 (*strongly agree*) to 7 (*strongly disagree*), with higher scores reflecting relatively greater life satisfaction, $\alpha = .90$.

Health behaviors

Two potentially relevant health behaviors were included.

Smoking status Smoking status of participants was assessed using participants' self-report of whether they were currently smoking cigarettes or not.

Physical activity level Physical activity level was assessed by creating categories accounting for participants' weekly vigorous, moderate, and mild sports/activity level. Participants were categorized into four levels of physical activity ranging from "Sedentary" to "High Activity," with higher scores representing greater physical activity [24]. Physical activity scores were recently validated using objective accelerometer measurements in the ELSA data and showed moderate correlation with self-report physical activity [29].

Biomarkers

Two biomarkers from the ELSA biomarker sample were used to assess inflammation and lung function.

CRP Blood samples were collected during house visits by trained nurses. The blood samples were then analyzed using standard lab procedures to assess CRP levels (mg/L [24]). These values were then log-transformed to normalize the distribution and CRP levels >10 mg/L were excluded ($n = 498$) from models including CRP, following standard practices [30].

Lung functioning Lung functioning was assessed using peak flow rate, measured in liters per minute. During ELSA nurse visits, participants exhaled into a handheld Vitalograph microspirometer peak flow meter three times and their highest satisfactory result was recorded. The highest satisfactory result was then used to create a percentage of predicted level for each participant based on their age, height, and gender: for men $\{\text{height in cm} \times 5.48 + 1.58 - [\text{age} \times 0.041]\} \times 60$, for women $\{\text{height in cm} \times 3.72 + 2.24 - [\text{age} \times 0.03]\} \times 60$. The percentage of highest satisfactory compared with predicted peak flow represented relative lung function. Lower peak flow rate predicts increased risk for early mortality over 5 years among aging adults [22].

Statistical Analyses

The hypothesized paths presented in Fig. 1 were modeled using path analysis structural equation modeling (SEM). The first model examined the association of marital dissolution and mortality (Model 1) in a broader sample of adults ($N = 6,003$) that included all participants who died from T1 (Wave 2) onward. We then specified a path analysis model (Model 2) that included two T2 health behaviors—smoking status and physical activity—as potential intermediate variables explaining the association of T1 marital status and mortality after Wave 4 ($N = 5,786$). In addition, we included smoking status predicting physical activity level [31]. In the final model (Model 3), we included T1 life satisfaction to test whether differences in psychological resources might predict people's later health behaviors, as well as two T3 biomarkers—lung functioning and CRP—that might explain the association of T2 smoking and physical activity with mortality. The measurement occasions for the variables of interest are presented in Fig. 3. The initial models including CRP were analyzed using a smaller sample, due to excluding participants ($n = 498$) whose

CRP scores were >10 mg/L [30], resulting in a smaller sample ($n = 5,288$). When we retained only the relevant variables for our final models, however, CRP was not included. As a result, our final sample for both Models 2 and 3 was 5,786. We included direct effects of age, gender, self-reported health, and wealth on all endogenous variables and reported standardized effects for all models to account for potential confounding effects from these alternative predictors. Finally, we also ran Model 1 moderated by gender and our final model in a multi-group SEM to determine whether there were differences in the models by gender.

All SEMs used probit regression with a theta parameterization and weighted root mean square residual as the estimator in MPLUS to account for dichotomous mediators (e.g., smoking status [32]). We used full likelihood maximum likelihood (FIML) estimation for missing data [33], and indirect effects were estimated using a bootstrapping approach ($N = 1,000$). Standardized values reported here were calculated using the formula $\beta = b \times SD(x)/SD(y)$ for continuous predictors, and $\beta = b/SD(y)$ for dichotomous variables, described in further detail in Muthén and Muthén (2011) [32]. To assess model fit, we used the root-mean-squared error of approximation (RMSEA) and comparative fit index (CFI), in addition to chi-square tests.

Results

Table 1 displays descriptive statistics and provides a correlation matrix of all variables included in the study estimated using FIML for the study participants from the final sample ($N = 5,786$).

As reported in Table 2, Model 1 examined the association between marital status and mortality. Participants who were separated/divorced at T1 evidenced a significantly increased risk for early mortality over the course of the ELSA study in the full sample, $\beta = 0.06$, 95% CI [0.02, 0.10], $p = .002$, $OR = 1.46$, 95% CI [1.15, 1.86]. These results suggest that separated/divorced adults had a 46% greater risk of death at the follow-up period compared with their still-married counterparts. This effect was attenuated when excluding participants who passed away from Wave 2–4, $\beta = 0.02$, 95% CI [−0.02, 0.06], $p = .360$, $OR = 1.16$; we ultimately excluded these participants to develop the full mechanistic model over

Fig. 3. Outline of the waves each of the variables of interest was sampled from.

Table 2 Full results for structural equation path models

Model 1			
Predicting mortality	β	95% CI	OR
Marital status	0.06**	[0.05, 0.13]	1.46**
Age	0.49**	[0.49, 0.57]	1.13**
Gender	−0.13**	[−0.33, −0.13]	0.55**
Self-reported health	0.26**	[−0.33, −0.13]	1.71**
Wealth	−0.06**	[−0.33, −0.13]	0.55
Model 2–Fit statistics			
No. of parameters	41		
Degrees of freedom	1		
χ^2	2.62		
RMSEA	0.017		
CFI	1.00		
Predicting T2 smoking	β	95% CI	B
Marital status	0.16**	[0.12, 0.20]	0.51**
Age	−0.21**	[−0.26, −0.16]	−0.03**
Gender	−0.04	[−0.08, 0.01]	0.10
Self-reported health	0.17**	[0.12, 0.22]	0.19**
Wealth	−0.41**	[−0.48, −0.34]	−0.26**
Predicting T2 physical activity	β	95% CI	B
Marital status	0.01	[−0.02, 0.04]	0.01
T2 smoking	−0.12**	[−0.17, −0.08]	−0.08**
Age	−0.21**	[−0.24, −0.18]	−0.02**
Gender	−0.11**	[−0.14, −0.08]	−0.18**
Self-reported health	−0.32	[−0.35, −0.29]	−0.23**
Wealth	0.02	[−0.01, 0.06]	0.01
Predicting mortality	β	95% CI	B
T2 smoking	0.14*	[0.02, 0.28]	0.15*
T2 physical activity	−0.12**	[−0.18, −0.06]	−0.19**
Age	0.46**	[0.42, 0.53] , −0.52]	0.06**
Gender	−0.11**	[−0.16, −0.06]	−0.27**
Self-reported health	0.13	[0.08, 0.18]	0.15**
Wealth	−0.05	[−0.17, 0.07]	−0.03
Model 3–Fit statistics			
No. of parameters	58		
Degrees of freedom	5		
χ^2	7.78		
RMSEA	0.010		
CFI	1.00		
Predicting T1 life satisfaction	β	95% CI	B
Marital status	−0.22**	[−0.25, −0.18]	−3.55**
Age	0.11**	[0.08, 0.14]	0.07**
Gender	0.02	[−0.01, 0.05]	0.30
Self-reported health	−0.30**	[−0.33, −0.27]	−1.64**
Wealth	0.04*	[0.01, 0.06]	0.11*

Table 2 *Continued*

Model 1			
Predicting T2 smoking	β	95% CI	B
T1 life satisfaction	0.02	[−0.03, 0.07]	0.00
Marital status	0.17**	[0.21, 0.13]	0.54**
Age	−0.21**	[−0.26, −0.16]	−0.03**
Gender	−0.04	[−0.09, 0.00]	−0.10
Self-reported health	0.18**	[0.13, 0.23]	0.20**
Wealth	−0.41**	[−0.48, −0.34]	−0.26**
Predicting T2 physical activity	β	95% CI	B
T1 life satisfaction	0.07**	[0.03, 0.10]	0.01**
T2 smoking	−0.10**	[−0.15, −0.05]	−0.07**
Age	−0.22**	[−0.25, −0.19]	−0.02**
Gender	−0.11**	[−0.14, −0.08]	−0.17**
Self-reported health	−0.30**	[−0.33, −0.27]	−0.22**
Wealth	0.02	[−0.01, 0.06]	0.01
Predicting T3 lung function	β	95% CI	B
T2 smoking	−0.43**	[−0.51, −0.35]	−0.92**
T2 physical activity	0.03	[−0.01, 0.07]	0.10
Age	−0.33**	[−0.57, −0.51]	−0.10**
Gender	−0.21*	[−0.25, −0.17]	−1.08*
Self-reported health	−0.05*	[−0.10, −0.00]	−0.12*
Wealth	−0.15**	[−0.21, −0.08]	−0.20**
Predicting mortality	β	95% CI	B
T2 smoking	0.08	[−0.06, 0.22]	0.08
T2 physical activity	−0.11**	[−0.17, −0.05]	−0.18**
T3 lung function	−0.15*	[−0.26, −0.04]	−0.07**
Age	0.41**	[0.34, 0.48]	0.06**
Gender	−0.14**	[−0.19, −0.09]	−0.35**
Self-reported health	0.12**	[0.07, 0.17]	0.14**
Wealth	−0.07	[−0.21, 0.07]	−0.05

Model 1 does not include fit statistics, as the model is fully saturated. T1 = Time 1, T2 = Time 2, T3 = Time 3. T3 Lung function values were divided by 100 and T1 Wealth values were divided by 100,000. *RMSEA* root-mean-squared error of approximation; *CFI* comparative fit index.

* $p < .05$; ** $p < .01$.

time. Although this effect was nonsignificant, excluding participants who died before Wave 4 disproportionately excluded deaths of separated/divorced adults, 56.8% of total deaths compared with 40.7%.

Model 2 included our candidate health behaviors at T2—smoking status and physical activity level—as intermediate variables explaining of the marital separation and mortality risk effect. The resulting model fit the data well, $\chi^2(1, N = 5,786) = 2.62, p = .106, CFI = 1.00, RMSEA = 0.017$, and is illustrated in Fig. 4. Being separated/divorced predicted a significantly greater likelihood of smoking, $\beta = 0.16 [0.12, 0.20], p < .001$, but did not predict physical activity level, $\beta = -0.01 [-0.04, 0.02], p = .372$. However, smoking predicted a

lower physical activity level, $\beta = -0.12 [-0.17, -0.06], p < .001$, which resulted in a significant indirect effect of separation/divorce on physical activity level via smoking status, $\beta = -0.02 [-0.03, -0.01], p < .001$. Physical activity, $\beta = -0.12 [-0.18, -0.06], p < .001$, and smoking status, $\beta = 0.16 [0.04, 0.28], p = .009$, independently predicted mortality, and fully mediated the association of marital status and mortality—total indirect effect, $\beta = 0.02 [0.00, 0.04], p = .012$.

Model 3 expanded the basic model specification to incorporate the additional psychological and biomarker variables outlined in Fig. 1. Being separated/divorced was associated with lower concurrent (T1) life satisfaction, $\beta = -0.22 [-0.25, -0.19], p < .001$. Greater life

satisfaction at T1 predicted higher physical activity level at T2, $\beta = 0.07$ [0.03, 0.10], $p < .001$, and separation/divorce was indirectly associated with physical activity via life satisfaction, $\beta = 0.03$ [0.02, 0.04], $p < .001$. Life satisfaction levels at T1 did not, however, predict greater likelihood of smoking at T2, $\beta = 0.02$ [-0.03, 0.07], $p = .466$, and separation/divorce remained significantly associated with later smoking status, $\beta = 0.17$ [0.13, 0.21], $p < .001$.

We then included lung function and CRP as candidate mediators that might explain the association of smoking and physical activity with risk for earlier mortality. The model with CRP excluded participants ($n = 498$) whose CRP scores were >10 mg/L [26], resulting in a smaller sample ($n = 5,288$). Although T2 smoking status and physical activity level predicted T3 CRP, T3 CRP did not predict mortality $\beta = 0.00$ [-0.03, 0.03], $p = .952$, whereas these associations were significant for lung functioning. Consequently, we retained only lung functioning in the final model, which also allowed us to retain the full sample ($N = 5,786$) for Model 3. Model 3 is illustrated in Fig. 5 and the full results of all three models are presented in Table 2. Self-reported T2 smoking, $\beta = -0.43$ [-0.51, -0.35], $p < .001$, but not physical activity level, $\beta = 0.03$ [-0.01, 0.07], $p = .177$, predicted lower T3 lung function levels. Lung function levels at T3 in turn predicted greater mortality risk over the subsequent 4 years, $\beta = -0.15$ [-0.27, -0.03], $p = .010$. Lung functioning fully mediated the association of mortality

with smoking, $\beta = 0.08$ [0.03, 0.13], $p = .005$, but did not mediate the association of mortality with physical activity, $\beta = -0.01$ [-0.02, 0.00], $p = .269$. Physical activity, but not smoking, at T2 remained directly associated with mortality, $\beta = -0.11$ [-0.17, -0.05], $p < .001$; $\beta = 0.08$ [-0.06, 0.22], $p = .254$. The final model fit the data well, $\chi^2(5, N = 5,786) = 7.78$, $p = .169$, CFI = 1.00, RMSEA = .010, and fully mediated the association of marital status and mortality, total indirect effect $\beta = 0.03$ [0.01, 0.05], $p = .005$. It is notable that if the final model included a direct association between marital status and mortality, this association was not reliably different from zero and in the opposite direction than would be expected, $\beta = -0.05$ [-0.09, 0.01], $p = .085$.

Gender Differences

There are broad gender differences in the link between being separated/divorced and risk of early mortality [2, 3]. As a result, we conducted a set of additional exploratory analyses by testing our models (specifically our initial and final models; Models 1 and 3) to determine whether the specific pathways of interest might vary between men and women. For Model 1, we moderated the association between marital status and mortality by gender. The results indicated that the association of marital status and risk of early death was greater for men than women, $\beta = 0.09$ [0.01, 0.17], $p = .038$, which

Fig. 4. Structural equation model testing the direct and indirect associations between marital status, health behaviors, and mortality status (Model 2). All values are standardized effect sizes. All endogenous variables were regressed on age, wealth, self-reported health, and gender. Marital status was assessed at T1 (Wave 2), physical activity level and smoking status were assessed 4 years later at T2 (Wave 4), and mortality was assessed over 4 years following Wave 4 (Waves 5–6). * $p < .05$, ** $p < .01$.

Fig. 5. Final structural equation model testing the direct and indirect associations between marital status and mortality including all variables of interest (Model 3). All values are standardized effect sizes. All endogenous variables were regressed on age, wealth, self-reported health, and gender. Marital status and life satisfaction were assessed at T1 (Wave 2), physical activity level and smoking status were assessed 2 years later at T2 (Wave 3), and lung functioning was assessed an additional 2 years later at T3 (Wave 4). Mortality was assessed over 4 years subsequent to T3 (Waves 5–6). * $p < .05$, ** $p < .01$.

matches previous research on the mortality risk associated with separation/divorce and gender [2, 3].

We also ran our final model, Model 3, using a multi-group SEM. For associations that differed between the two groups, we constrained the associations to equality between men and women and assessed whether this resulted in a significant change in nested model fit, $[\chi^2_{\text{Model 2}} - \chi^2_{\text{Model 1}} (df_{\text{Model 2}} - df_{\text{Model 1}})]$. The results revealed two differences of interest based on participants' gender. First, the association between marital status and life satisfaction was significantly greater for women, $\beta = -0.30$, $p < .001$, than for men, $\beta = -0.17$, $p < .001$, $p = .085$, $\chi^2(1, N = 5,786) = 13.42$, $p < .001$. The result suggests that women have a stronger association between their marital status (separated/divorced compared with married) and life satisfaction than men. Second, there was a stronger association between physical activity and mortality for women, $\beta = -0.15$, $p = .001$, than for men, $\beta = -0.06$ $[-0.09, 0.01]$, $p = .054$, though freeing the equality constraint did reach a traditional cut-off for statistical significance, $\chi^2(1, N = 5,786) = 3.78$, $p = .052$. None of the other associations of interest reduced model fit when setting men and women's associations to equality.

Discussion

Although the association between marital status—specifically being separated or divorced—and risk for early death is well established [2, 3], studying the biobehavioral pathways that might explain this broad-based effect remains an important area for research. This report used data from a sample of 5,786 aging adults (mean age = 63.14) drawn from English Longitudinal Study (ELSA) to examine putative psychological, behavioral, and biomarker variables that might explain the association of marital status and greater risk of mortality. In this sample, being separated or divorced was associated with lower life satisfaction levels compared with being married at the first assessment, and lower life satisfaction levels predicted lower physical activity levels 2 years later, whereas marital status remained directly associated with smoking status. Smoking, in turn, predicted decreased peak lung function an additional 2 years later, and decreased lung function was associated with greater risk for early mortality over the subsequent 4 years. Physical activity level also directly predicted subsequent mortality. These pathways fully accounted for the total effect linking marital status to later mortality risk in this sample. Notably, these results were above and beyond the effect of age, gender, self-reported health, and wealth, suggesting that the differences between married and separated/divorced adults' outcomes cannot be accounted for by the measured health status or demographic variables alone.

The additional analyses examining differences by gender revealed two effects that seem to be in contrast

to each other. Men were at higher risk of early death compared with women when separated/divorced, which matches well with previous meta-analytic results [2, 3]. Women, however, had a stronger association between their marital status and life satisfaction, such that separated/divorced women had significantly lower levels of life satisfaction than separated/divorced men when compared with their married counterparts. These results suggest that women in this cohort may face greater risk for poorer psychological well-being, whereas men face greater risk for negative health outcomes, specifically greater risk of mortality. This effect may indicate a difference in how separated/divorced men and women cope with lower levels of life satisfaction that was not assessed in the current study. Future research should examine how separated/divorced men and women might differ in their behavioral responses to lower life satisfaction.

The contributions of this work to the study of marital status and health are substantial. There are large differences in the way health behaviors unfold in a marriage compared with people who are separated or divorced. Married adults report that their spouse is the most frequent person to remind them about their health and health behaviors [7], something that by definition does not occur for those outside marriage. These associations do not seem to be exclusively due to selection effects. Genetically informed research suggests that changes in smoking behavior appear to be a causal consequence of changes in marital status [34], and this work is supported by evidence that marital dissolution increases risk for smoking relapse among women who were prior smokers [35]. Results from the current analyses build on these prior findings by demonstrating that (a) marital status is directly associated with smoking status, whereas lower levels of life satisfaction for separated/divorced adults (relative to their married counterparts) fully explain physical activity levels and (b) smoking status, in turn, predicts lung functioning levels that partially account for the overall early mortality risk, whereas physical activity directly predicts mortality status. Decreased lung capacity among smokers is not a novel finding, but the identification of a specific path from being separated/divorced to *subsequent* smoking status and physical activity to *subsequent* lung functioning levels, which then predicts *subsequent* mortality is a new contribution to the literature. To our knowledge, this is the first paper to specify and test a full potential path analysis from marital status—specifically being separated or divorced compared with married—to risk for early mortality through candidate psychological, health behavior, and biomarker variables.

It is important to note, however, that some of the pathways in our hypothesized biobehavioral pathway were not fully explained by the prior intervening variables. For example, the main effect of marital status predicting smoking status remained when including psychological

well-being as a mediating variable. These results suggest that there might be additional explanatory variables that might account for this association, and these additional links might be alternative intervention targets for future research. We also hypothesized that social control of health behavior might explain some of the impact of marital status, but were unable to directly test variables assessing social control of health due to the measures available in the ELSA dataset. Future work examining this association might benefit from measures that specifically assess the social control of health or other potential psychological processes that might link marital status and health behavior. Poor health outcomes associated with separation/divorce appear to be driven in large part by a subset of people who have a tendency to become immersed in their experience and/or with a history of prior mental health difficulties [36]. It is possible that a subset of aging adults is primarily responsible for the associations of interest in the current study. Indeed, it is possible that some people gain health benefits following separation/divorce and the removal of negative influences, particularly in low quality marriages or marriages in which one partner has much poorer health behaviors than their spouse. Women in very low quality marriages, for example, gain life satisfaction following separation/divorce [37], and aging women who transition out of marriage have increased physical activity levels compared with women who remain married [38]. Future studies should seek to identify who is at greatest risk for poorer psychological well-being or health-compromising behaviors following separation/divorce, as well as whose health might benefit from separation/divorce.

Although the effect of smoking predicting mortality was fully explained by lung function, this was not the case for physical activity level in our models. Although a portion of the risk for early death is attributable to lung functioning, it makes sense that additional biomarkers might help explain the association of physical activity and mortality. Smoking is frequently linked to health conditions that might affect lung functioning, such as lung cancer or emphysema, but other conditions linked to physical activity levels, including diabetes or cardiovascular disease [39, 40], might affect different biomarkers. These alternative pathways would suggest candidate biomarkers that might be useful in studying the link between health behaviors and mortality risk for separated or divorced adults. The results may have important clinical implications. Smoking and physical activity accounted for the greater risk for early mortality among separated/divorced adults, and targeting these clear intervention targets for such adults as a potentially at-risk group may produce long-term health benefits. Similarly, behavioral or psychopharmacological treatments that improve psychological well-being for separated/divorced adults may also mitigate the deleterious

effects of sedentary behavior associated with those who have experienced marital dissolution. Ultimately, experimental research will be needed to determine whether improving life satisfaction, increasing physical activity, or decreasing smoking behavior can reduce the long-term mortality and morbidity risks associated with being separated or divorced.

Despite the longitudinal, representative nature of the ELSA sample, the results of these analyses should be considered in light of the study's limitations. First, the current sample was drawn from a study of aging adults and it is unclear whether these effects generalize to younger cohorts. For example, this sample included aging adults that have survived to older age, which could have excluded people who died at earlier ages, biasing the current results. Second, although our conceptual model included relevant psychological, health behavior, and biomarker variables, multiple alternative health behavior variables—such as alcohol consumption, body mass, and diet—may explain this health risk as well. Research examining the association of marital status and health will continue to benefit from the interrogation of specific mechanisms in smaller-scale studies that afford opportunities for detailed measurement of psychosocial and health processes. Third, our models used levels of the outcomes of interest, rather than examining change in those outcomes (e.g., change in smoking status). This was an intentional choice, as the timing of assessments and the separation/divorce having likely occurred years earlier meant effects from marital dissolution were likely present at the initial assessment. Future research should target the period immediately following marital dissolution to determine whether these outcomes of interest change in the period following marital dissolution. Fourth, although combining separation and legal divorce into a single group is common practice when studying marital dissolution, this may have obscured differences between these groups. Finally, marital status was assessed at the study's start, but it is possible participants' marital statuses changed across the study time period. Notably, excluding participants whose marital status changed during the study ($n = 679$) did not change the substantive results of the study.

Conclusions

In a representative, longitudinal sample of aging adults, the risk for earlier mortality among separated/divorced people was fully explained by smoking behavior and physical activity level. The association of marital status and physical activity was fully explained by differences in life satisfaction, whereas marital status remained directly associated with smoking status. Finally, the link between smoking status and risk for early mortality was fully accounted for by differences in lung function, but

physical activity remained directly associated with early mortality. These results suggest that interventions targeting smoking, physical activity, and life satisfaction may have the potential to mitigate a portion of the risk for earlier mortality associated with being separated or divorced.

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Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards The authors declare that they have no conflict of interest. The authors did not directly collect the data involving human participants. The original English Longitudinal Study of Ageing reported complying with all ethical requirements for human subjects.

Informed Consent The data reported in our manuscript was from a secondary dataset that was collected by a separate team and made available for researchers, so all informed consent for the participants in the current study was collected by the data collection team from the English Longitudinal Study of Ageing (ELSA) study.

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