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Trajectories of Depressive Symptoms in Old Age: Integrating Age-, Pathology-, and Mortality-Related Changes

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Abstract

Late life involves a variety of different challenges to well-being. This study extends upon and qualifies propositions drawn from the paradox of well-being in aging using 15-year longitudinal data on depressive symptoms from old and very old participants in the Australian Longitudinal Study of Ageing (at baseline $n = 2,087$, M age = 78.69 years, range = 65-103 years; 49.40% women). We first examined age-related trajectories in depressive symptoms from young-old to oldest-old, taking into account (changes in) relevant correlates, pathology, and mortality, and, second, investigated gender differences in these trajectories. Results revealed that age-related trajectories of depressive symptoms were indeed predictive of mortality hazards. The unique predictive effects of both level of, and change in, depressive symptoms were independent of one another and hold after taking into account education as well as changes in marital status, living arrangements, cognitive function, and illness burden. In addition, results indicated that depressive symptoms were elevated among participants suffering from arthritis, and increased with age more markedly in men than in women. In particular, the significant age by gender interaction indicated that the gender gap in depressive symptoms reduced from young-old to old-old and reversed in very old age when men showed more depressive symptoms than women. Qualifying the paradox of well-being in aging, findings demonstrate that depressive symptoms increased from young-old to oldest-old and suggest that age-, pathology-, and mortality-related changes should be examined in concert to advance our understanding of individual differences in depressive symptom trajectories in late life. (Word count: 248)

Keywords: aging, depressive symptoms, mortality, arthritis, joint longitudinal-survival model

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Related Changes

Late life involves many challenges with consequences for changes in well-being (Baltes,

1997; Berg, 1996; Birren & Cunningham, 1985). Yet, in contrast to age-normative declines in

physical health and cognitive functioning, a myriad of studies provide empirical evidence of a

relative stability or even improvement in well-being in old age (Charles & Carstensen, 2010;

Charles, Reynolds, & Gatz, 2001; Mather, 2012; Mroczek & Kolarz, 1998). This preservation of

well-being despite age-related losses has been coined "the stability paradox of well-being in

aging" (Kunzmann, Little, & Smith, 2000; Mather, 2012). From our perspective, however, the

empirical evidence for the paradox has three important limitations. First, evidence mostly

concerns age-related changes in the cognitive component of subjective well-being (e.g., life

satisfaction; Diener, Suh, Lucas, & Smith, 1999; Gana, Bailly, Saada, Joulain, & Alaphilippe,

2013), whereas results regarding age-related changes in affective components of subjective well-

being are less clear (Schilling, 2006). Second, the well-being paradox may hold only until early

old age and less is known about life periods for which major loss experiences are frequent such

as old-old and oldest-old age (Baltes & Smith, 2003). Third, a major challenge for research

examining age-related changes in well-being pertains to the fact that development is shaped by

the interplay between age-, pathology-, and mortality-related processes (Baltes, Lindenberger, &

Staudinger, 2006). Ignoring pathology- and mortality-related processes can lead to biased

estimates in age-related changes, such that depressive symptoms in very old age are likely

underestimated because of selective attrition due to pathology and mortality (Mirowsky &

Reynolds, 2000). For instance, findings from the Veterans Affairs Normative Aging Study

revealed that men who died within one year after assessment showed a faster rate of decline in life satisfaction than men who survived (Mroczek & Spiro III, 2005).

In the present study, we therefore focused on examining age-related trajectories of depressive symptoms, an affective component of subjective well-being, across an age spectrum ranging from young-old (65-75 years) to the oldest-old (85 years and above; Baltes & Smith, 2003; Neugarten, 1996). We made use of longitudinal information about depressive symptoms from 2,087 older adults who participated for up to 15 years (1992-2007) in the Australian Longitudinal Study of Ageing (ALSA; Luszcz et al., 2014). Instead of taking conventional approaches, such as multilevel modeling, that assume dropouts are missing at random, we argue that a joint modeling of age-related trajectories and survival data offers a fruitful avenue to extend past research toward a better understanding of age-related changes in depressive symptoms and their associations with pathology and mortality in old age (Graham, Ryan, & Luszcz, 2011; Zhang, Kahana, Kahana, Hu, & Pozuelo, 2009). Our objectives therefore were two-fold. First, we examined the pattern of age-related changes in depressive symptoms from young-old to oldest-old, taking into account (changes in) relevant correlates of well-being, pathology, and mortality (Alberta Health, 2003; Murray et al., 2012) that are known risk factors for impaired well-being. Second, considering gender differences in the level of, and age-related changes in, depressive symptoms (Barefoot, Mortensen, Helms, Avlund, & Schroll, 2001), we examined how findings regarding the so-called paradox of well-being may differ between men and women.

Paradox of Well-Being

Developmental change involves both growth in, and losses of, functional capacity, with the proportion of losses increasing and that of gains decreasing with aging (Baltes et al., 2006).

Frequently referred to as the *gain-loss dynamic*, this increasingly negative general pattern with advancing age, the myriad of empirical reports attesting to the average stability of well-being into old age are surprising (Carstensen et al., 2011; Charles et al., 2001). For example, life satisfaction increased over an 8-year period in a sample of older adults ($n = 899$, M age $= 72.73$ years, age range $= 62$-95 years), controlling for covariates such as gender, education, and self-perceived health (Gana et al., 2013). In addition, positive affect remained stable from young to middle-age ($n = 2,804$, age range $= 15$-90 years at baseline) and showed only modest decline into old age. Furthermore, negative affect decreased over a 23-year period (Charles et al., 2001). This maintenance of well-being despite age-related losses has been coined "the stability paradox of well-being in aging" (Kunzmann et al., 2000; Mather, 2012).

Changes in Depressive Symptoms as Related to Age, Pathology, and Mortality

It is increasingly recognized that changes in depressive symptoms and other aspects of well-being may be due to age-, pathology- and/or mortality-driven changes (Baltes & Smith, 2003; Fauth, Gerstorf, Ram, & Malmberg, 2014; for an overview, see Gerstorf & Ram, 2013; Infurna, Gerstorf, & Ram, 2013; Schilling, Wahl, & Reidick, 2013; Zhang et al., 2009). In the following, we review the literature on the role of these three dimensions of changes in depressive symptoms.

The role of age. Evidence suggests that depressive symptoms increase in old age (Zarit, Femia, Gatz, & Johansson, 1999). However, findings regarding the age-related trajectory of depressive symptoms in old age remain inconclusive in part due to differences in sample composition. Few studies have used samples covering the entire older adulthood period, spanning from young-old to oldest-old (For exceptions, see Byers et al., 2012; Clarke, Marshall, House, & Lantz, 2011). For example, during a 20-year period, 20% of a sample of community-

dwelling women 65 years or older (n = 7,240 at baseline) actually showed persistently high or increasing depressive symptoms (Byers et al., 2012). The variation in patterns of age-related changes, may suggest that some older adults may be more protected against depression due to socio-emotional selectivity and wisdom (Blazer & Hybels, 2005). Others may be more at risk due to limitations in these and other attributes. Thus, claims of age-related changes in depressive symptoms need to take into account the (changes in) adversities and protective factors in old age (Blazer & Hybels, 2005).

The role of pathology. The association between age and depressive symptoms, often arises in the context of age-related changes in chronic health conditions and disability (Alexopoulos, 2005; Blazer, 2003). Instead of life-threatening health conditions, the present study focused on arthritis, the most common chronic health condition (Australian Institute of Health and Welfare, 2014; Hootman, Helmick, & Brady, 2012).

Arthritis is diagnosed in 14.8% of the Australian population (Australian Institute of Health and Welfare, 2014). The prevalence of arthritis increases with age and is highest among those aged 75 years or above, with about half of this cohort in Australia having arthritis (Australian Government, 2010). Similarly, in the Australian Longitudinal Study of Ageing, 54% of the sample of 2,087 individuals over the age of 65 years reported having arthritis (Caughey et al., 2010). In addition, individuals with arthritis rated their pain as the most severe, among 22 chronic health conditions including back pain, migraine, and heart disease (Alberta Health, 2003). Past research has shown that a higher intensity of chronic pain is associated with a higher level of depressive symptoms and a higher level of negative affect in everyday life (Tennen, Affleck, & Zautra, 2006; Zautra, Smith, Affleck, & Tennen, 2001). Using a sample of individuals living with arthritis for an average of 10 years (n = 423, M age = 44.5 years, 88% women), Sirois and

Hirsch (2013) reported pain severity to be positively associated with depressive symptoms at baseline. In the six-months follow-up, pain severity was associated with depressive symptoms, controlling for depressive symptoms at baseline (Sirois & Hirsch, 2013). In addition, among married individuals with rheumatoid arthritis (RA), both baseline and one-year changes in RA symptoms including pain, were associated with depressive symptoms in the spouse (Lam, Lehman, Puterman, & DeLongis, 2009). These results suggest that although chronic conditions such as arthritis are not life threatening (Caughey et al., 2010), individuals with arthritis experience chronic pain that is associated with losses in emotional well-being (Marks, 2013) and may also have consequences for spouses.

The role of impending mortality. For mortality-related processes, findings from a meta-analysis have shown that a higher level of depressive symptoms in old age is associated with a higher risk of mortality (Saz & Dewey, 2001). For example, depressive symptoms predicted mortality over a five-year period in a sample of community-dwelling older adults, *M* age = 76.2 years (St John & Montgomery, 2009). Likewise it has been shown that change in depression status (i.e. never depressed, incident depression, remitted depression, and chronic depression; measured using the recommended CES-D cutoff of 16; Radloff, 1977) over a period of two years was associated with mortality in the subsequent six years (Anstey & Luszcz, 2002). Compared to the never depressed group, the incident depression and chronic depression groups had a higher risk of mortality but the remitted depression group did not. The association between depressive symptoms and mortality, however, may depend on the length of the follow-up period. In general, the strength of the association between depressive symptoms and mortality tends to be smaller with longer follow-up periods (Saz & Dewey, 2001), during which other factors may be more consequential.

Integrating Age-, Pathology-, and Mortality-Related Changes

Lifespan psychological theories and empirical findings demonstrate that age-, pathology-, and mortality-related processes conjointly shape aging trajectories across domains of functioning (Aldwin & Gilmer, 2013; Baltes et al., 2006). For instance, one way to better understand the associations between depressive symptoms and mortality in old age is to concurrently track longitudinal changes in depressive symptoms and their association with mortality (Zhang et al., 2009). However, conventional methods of longitudinal data analysis assume dropouts to be missing at random (Graham et al., 2011; Rizopoulos, 2012), which may lead to biased estimates, such as underestimation of depressive symptoms in advanced age (Mirowsky & Reynolds, 2000). Recent developments in longitudinal statistical methodology such as joint modeling have been shown to be effective tools for handling the challenge of modeling longitudinal changes with dropouts due to mortality (Graham et al., 2011; Rizopoulos, 2012). The basic rationale of joint modeling is to simultaneously model the longitudinal data and the survival data, i.e. joining the multilevel model and survival model (Rizopoulos, 2012). For example, joint modeling has been fruitfully applied in the examination of the association between longitudinal changes in cognitive functioning and mortality (Ghisletta, 2008; Ghisletta, McArdle, & Lindenberger, 2006; Graham et al., 2011).

Recently, joint modeling has been applied to data from the Florida Retirement Study. Results indicate that an increase in depressive symptoms over 11 years was associated with higher mortality rates in older adults (Zhang et al., 2009). Specifically, using time-in-study as the time metric, an annual increase of one point in depressive symptoms was associated with a 1.57-fold increase in mortality, controlling for baseline covariates including age, gender, education, marital status, living arrangement, cognitive functioning, and illness burden. Interestingly, the

baseline level of depressive symptoms was not associated with mortality. These findings point to the importance of examining between-person differences in individuals' trajectories of depressive symptoms to further our understanding of the link between age, mortality, and depressive symptoms (Byers et al., 2012; Schilling et al., 2013; Zhang et al., 2009).

Gender, Depressive Symptoms, and Mortality

Gender difference is an important between-person difference in individuals' trajectories of depressive symptoms (Barefoot et al., 2001; Mirowsky, 1996) and mortality (Franceschi et al., 2000). For example, Franceschi et al. (2000) reported lower mortality risk in women than men across all age groups, reflecting differences in their genetic makeup and lifestyle choices that have implications for longevity. Hence the gender gap in depressive symptoms may be expected to vary with age because of gender differences in the exposure to risk factors (Mirowsky, 1996). For example, women tend to experience more chronic health conditions, such as arthritis, and are more likely to be widowed in old age, which may predispose them to more depressive symptoms, thus widening the gender gap with increasing age. Previous studies showed conflicting results with regard to gender differences in how depressive symptoms may change with age. Using cross-sectional data from three US samples, findings showed that depressive symptoms decreased in successive age groups from young adulthood to early old age and increased from early old age to oldest-old for both men and women, with an increasing gender gap from young adulthood to oldest-old age (Mirowsky, 1996). Specifically, from young adulthood to early old age, the decrease in depressive symptoms across age groups was steeper in men than in women. From early old age onwards, the increase in depressive symptoms across age groups was steeper in women than in men, resulting in a wider gender gap across the entire period of adulthood such that women showed increasingly more depressive symptoms than men across age groups. In

contrast, using longitudinal data from Denmark, findings revealed a <u>decreasing</u> gender difference in depressive symptoms between age 60 to 80 (Barefoot et al., 2001). Specifically, women showed a higher level of depressive symptoms than men from age 60 to 80. However, men showed increases in depressive symptoms during the same period but women did not.

Covariates: Cognitive Functioning and Illness Burden

Comorbidity and cognitive functioning may be among the underlying variables that drive age-related changes in depressive symptoms and other aspects of health (Gerstorf, Ram, Lindenberger, Röcke, & Smith, 2008; Gerstorf, Ram, Lindenberger, & Smith, 2013). In this study, we explored whether the associations between the age-related changes in depressive symptoms, arthritis diagnosis, and mortality remained after controlling for education, and age-related changes in living arrangement, marital status, cognitive functioning, and illness burden (Anstey, von Sanden, Sargent-Cox, & Luszcz, 2007; Maier & Smith, 1999; Pessin, Rosenfeld, & Breitbart, 2002; Rapp, Gerstorf, Helmchen, & Smith, 2008).

The Current Study

In this study, we examined associations between age-related changes in depressive symptoms, arthritis diagnosis, and mortality, using a large sample from the Australia Longitudinal Study of Ageing (ALSA; Luszcz et al., 2014) to corroborate and extend findings from the Florida Retirement Study (n = 897; Zhang et al., 2009) in two ways. First, rather than using time-in-study, we used chronological age as the time metric (Ghisletta et al., 2006; Graham et al., 2011), which allows us to examine whether depressive symptoms increase as individuals develop into advanced age. Thus, the use of chronological age instead of time-in-study as the time metric allows a more direct operational definition of propositions of the paradox of well-being. Second, instead of controlling for baseline covariates only as in the Florida Retirement

study, our examination of age-related changes in depressive symptoms controlled for the changes in covariates including illness burden, cognitive functioning, living arrangement, and marital status (for more details see the section "Covariates: Cognitive Functioning and Illness Burden"). We expected that depressive symptoms would increase with age and that a higher level of, and increases in, depressive symptoms across older adulthood would each be associated with increased risks of death, after we had taken into account (changes in) these covariates.

We examined the following hypotheses. First, depressive symptoms would increase from young-old to oldest-old age. Second, age-related increases in depressive symptoms would be associated with the presence/incidence of arthritis. Third, age-related changes in depressive symptoms would be significant predictors of death. Specifically, we hypothesized that age-related increase in the level and slope of depressive symptoms would each be associated with increased risks of mortality. Finally, drawing from the results of decreasing gender difference in depressive symptoms from young-old to old-old from a longitudinal sample (Barefoot et al., 2001), we hypothesized that women in general would show a higher level of depressive symptoms than men. However, gender differences in depressive symptoms would be smaller in oldest-old than in young-old adults.

Method

Participants

This study used data from the Australian Longitudinal Study of Ageing (ALSA; Luszcz et al., 2014). Potential participants were randomly selected from the South Australian Electoral Roll, for which registration is compulsory for Australian citizens. The sampling procedure and sample characteristics have been described elsewhere (Andrews, Clark, & Luszcz, 2002). In brief, individuals aged 70 years or more registered on the Electoral Roll were eligible for the study. A

total of 1,477 (56%) eligible people took part in Wave 1 in 1992. Spouses of participants who

were 65 years or older and co-residents over 70 years of age were also invited to participate. At

baseline, 2,087 older adults (*M* age = 78.16 years, *SD* = 6.69 years, age range = 64.90-103.50

years, women = 49.4%) took part. The measures pertinent to the present study were collected on

five occasions: Wave 1 (September, 1992-February, 1993), Wave 3 (September, 1994-February,

1995), Wave 6 (September, 2000-February, 2001), Wave 7 (September, 2003-April, 2004), and

Wave 9 (November, 2007-June, 2008). In addition, participants' survival status was based on the

date of death obtained and censored at February 2012, from the Births, Deaths and Marriages

Registration Office, South Australia (see Anstey, Luszcz, Giles, & Andrews, 2001 for details).

At that time, 1,721 (82.46%) participants were dead.

Measures

      Depressive symptoms. The 20-item Center for Epidemiologic Studies Depression Scale

was used to assess depressive symptoms (CES-D; Radloff, 1977). Participants rated their

depressive symptoms in the last two weeks on a 4-point scale (0 = *Rarely or none of the time*; 3

= *Most or all of the time*). The possible scores range from 0-60. Higher scores indicate greater

degrees of depressed mood. Mean substitution was performed when less than 20 percent of

responses were missing. Cronbach's alphas ranged from .78 in Wave 1 to .84 in Wave 3,

suggesting satisfactory internal consistency across waves. Table 1 presents descriptive statistics

of depressive symptoms by waves.

      Arthritis diagnosis. At each wave, participants reported whether or not they received a

current arthritis diagnosis from their doctors. In Wave 1, 54% of participants reported a current

arthritis diagnosis. The proportion of participants reporting an arthritis diagnosis in our study was

comparable to results of the National Health Interview Survey, which 49.7% of participants aged

65 years or above reported an arthritis diagnosis (Centers for Disease Control and Prevention, 2013). Table 1 presents the percentages of participants who reported an arthritis diagnosis at each wave.

Survival status. Survival status was established by participants' exact date of death, obtained from the Births, Deaths and Marriages Registration Office, South Australia. The mean age of death was 87.80 years ($SD = 6.33$ years; range = 68.9-109.2 years). The age of death differed significantly between men (87.30 years) and women (88.41 years), $t(1604) = -3.58$, $p < .001$.

Covariates. The effects of education, marital status, living arrangement, cognitive function, and illness burden were controlled for in the models examined. At Wave 1, education was assessed in terms of whether participants stayed in school beyond age 14 (0 = *left school*; 1 = *stayed in school*); 44% of participants stayed in school beyond age 14. Cognitive function was assessed using the Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). Illness burden was assessed using the number of medical conditions, assessed by responses to questions on a comprehensive list of 37 diseases, and difficulties with activities of daily living. Table 1 shows the descriptive statistics for the covariates.

Statistical Analyses

Joint modeling of longitudinal change and survival allows the simultaneous estimation of longitudinal and survival information (Rizopoulos, 2012). The joint model is specified by treating the longitudinal and the survival models as two sub-models, with an association parameter, α, to link up the two sub-models. Interested researchers may refer to Rizopoulos' (2012) work and its associated web resources, http://jmr.r-forge.r-project.org, for details of the theory and application of joint modeling.

To examine the association between age-related changes in depressive symptoms on mortality, chronological age was used to represent developmental time. The basic longitudinal sub-model can be represented as follows:

Level-1 model:

$$D_{it} = b_{0i} + b_{1i}age_{it} + e_{it} \tag{1}$$

Level-2 model:

$$b_{0i} = a_{00} + u_{0i} \tag{2}$$

$$b_{1i} = a_{10} + u_{1i}$$

D_{it} is depressive symptom for individual i at time t. Following previous studies (Ghisletta, 2008; Ghisletta et al., 2006), age is grand-mean centered at 64.90 years, the age of the youngest participant at Wave 1. a_{00} and a_{10} are fixed effects, which respectively represent the mean intercept and the mean effect of age on depressive symptoms. u_{0i} and u_{1i} are random effects, which respectively represent the individual-specific variations from the means. We also examined the effects of gender, gender by age interaction, and the quadratic effect of age. Joint modeling of longitudinal and survival sub-models requires parametric models (Ghisletta et al., 2006; Rizopoulos, 2012). Therefore, the widely used non-parametric Cox survival model cannot be used. We used the Weibull survival model, a commonly used parametric model for survival functions (Therneau & Grambsch, 2000). The basic Weibull survival model can be represented using the following equation:

$$\lambda_i(t) = (r \cdot t^{r-1}) \exp(\gamma_0) \tag{3}$$

The term $r \cdot t^{r-1}$ is the Weibull hazard function with $r > 0$. r is the shape parameter. When $r = 1$, the Weibull model reduces to the exponential model. In the exponential model, the risk that the event occurs is constant across time. When $r > 1$, the risk of the event occurring increases with time. In contrast, When $0 < r < 1$, the risk of the event occurring decreases with time. $\lambda_i(t)$ is the relative risk at time t, for individual i. γ_0 is the intercept. Chronological age was used as the time metric, t, which is grand-mean centerd at 64.90 years, the age of the youngest participant at Wave 1. In the basic joint model, the two basic sub-models (Eqs. 1, 2, and 3) are linked up by the association parameter, α (Rizopoulos, 2012).

$$\lambda_i(t) = (r \cdot t^{r-1}) \exp\{\gamma_0 + \alpha m_i(t)\}, \tag{4}$$

where $m_i(t) = a_{00} + u_{0i} + (a_{10} + u_{1i}) \text{age}_{it}$.

In this basic joint model represented by Eq. 4, the fitted longitudinal value, i.e., age-related trajectory of depressive symptoms, is associated with the hazard rate. The association parameter, α, represents the effect of the current values of the longitudinal measures of depressive symptoms on the risk of death. In the next step, all baseline covariates, including gender and education, were added into the survival sub-model and all time-varying covariates, including marital status, living arrangement, cognitive functioning, and illness burden, were added into the longitudinal sub-model. Finally, arthritis diagnosis was entered into the longitudinal sub-model.

Results

As a first step, we tested a series of multilevel models to examine the functional form of the longitudinal trajectory before fitting the joint models of longitudinal and survival data. This determines the relative fit of a linear vs. a curvilinear model of age on depressive symptoms. The linear and quadratic effects for age, gender, and the interaction effect for age $\times$ gender were

examined. All control variables, including education, living arrangement, marital status, cognitive functioning, and illness burden, were entered in this model. The best fitting model showed that depressive symptoms increased with age, $a_{10} = .09$, $t(2605) = 4.85$, $p < .001$. In addition, women reported more depressive symptoms than men, $a_{01} = 2.47$, $t(2023) = 4.51$, $p < .001$. However, the effects of age and gender need to be interpreted in the context of the significant age $\times$ gender interaction, $a_{11} = -.13$, $t(2605) = -3.90$, $p < .001$. Compared to women, men showed a steeper rate of increase in depressive symptoms. An alternative model showed that the quadratic effect of age was not significant, $a_{20} = -.001$, $t(2604) = -.71$, $p > .05$. Additional preliminary analyses were performed to determine the effects of age, gender, and arthritis on depressive symptoms across waves. This information is available as an online supplement. Results of multilevel modeling showed that the effects of age, gender and the interaction of age $\times$ gender need to be considered in the longitudinal sub-model of the joint model, which is an important precondition to proceeding to the next step.

We then proceeded to address the hypotheses, regarding (a) the examination of age-related changes in depressive symptoms taking into account (changes in) cognitive function, illness burden, arthritis, and mortality, and (b) gender differences in age-related changes in depressive symptoms. *Table 2* presents the parameter estimates of two joint models of longitudinal and survival data. Model 1 examined the effects of age, gender, and age $\times$ gender interaction, with time-varying covariates added in the longitudinal sub-model and baseline covariates added in the survival sub-model. Results of the longitudinal sub-model of Model 1 are graphically presented in *Figure 1a*. Model 2 examined the effect of arthritis diagnosis, above and beyond the effects examined in Model 1. An additional model adding the quadratic effect of age to Model 2 was fitted but could not be estimated due to model complexity. Based on AIC and

BIC, Model 1 provided the best fit. Results of the likelihood ratio test showed that the more complicated Model 2 did not fit significantly better than Model 1, $\chi^2(1) = .65$, $p > .05$. However, because of our interest in the association between arthritis diagnosis and depressive symptoms, results of Model 2 were used for further interpretation. Results of the longitudinal sub-model of Model 2 are graphically presented in *Figure 1b*. Depressive symptoms increased with age, $a_{10} = .11$, $z = 6.68$, $p < .001$. For gender differences, women reported more depressive symptoms than men, $a_{01} = 2.40$, $z = 5.36$, $p < .001$. The age by gender interaction effect was significant, $a_{11} = -.14$, $z = -5.35$, $p < .001$. The interaction effect indicates that compared to women, men showed larger increases in depressive symptoms with age. In addition, individuals with a current arthritis diagnosis reported more depressive symptoms, $a_{20} = .55$, $z = 3.02$, $p < .01$.

All control variables were significantly associated with both the level and slope of depressive symptoms, all ps $< .05$. Briefly, a higher level of depressive symptoms was associated with individuals who were not married, living in the community, having lower cognitive function, greater illness burden, and more difficulties in activities of daily living. In addition, a faster rate of increase in depressive symptoms was associated with lower cognitive functioning, more medical conditions, and more difficulties in activities in daily living.

In the survival sub-model of Model 2, the effects of gender, and number of medical conditions significantly predicted the risk of death. Compared to men, women had a lower risk of dying, $\gamma_1 = -.30$, $z = -6.10$, $p < .001$. The effect of education on the risk of dying was not significant, $\gamma_2 = -.02$, $z = -.40$, $p > .05$. The association parameter, $\alpha = .02$, $z = 5.14$, $p < .001$, indicated that the age-related changes in depressive symptoms were positively associated with mortality, such that exp (α) = 1.02, denotes the ratio of hazards for one unit change in the trajectory at any time. Specifically, a one-unit increase in the level (i.e., intercept) and an annual

increase of one-unit (i.e., slope) in depressive symptoms were associated respectively with 1.17- and 1.002-fold increase in relative risk of death. The logarithm of the shape parameter, log(*shape*) = 1.39, $z = 70.88$, $p < .001$, indicates that the risk of death increases with advancing age. Although the relative fit between the multilevel model and the joint models cannot be compared using the model fit indices, the significant effect of the association parameter, α, suggests that attrition due to mortality was nonrandom and was associated with the longitudinal trajectory of depressive symptoms.

Discussion

The present study examined age-related trajectories of depressive symptoms and their association with mortality in old and very old age taking into consideration pathology-related changes to extend and qualify previous findings regarding the so-called paradox of well-being in old age. Four major findings emerged from this study. First, in contrast to propositions of the paradox of well-being, depressive symptoms increased from young-old to oldest-old age. Second, the level of depressive symptoms was associated with arthritis diagnosis. Individuals with arthritis reported a higher level of depressive symptoms than those without arthritis. Third, both the level of, and change in, depressive symptoms were associated with mortality, suggesting poorer emotional functioning as death approaches. Fourth, the significant age by gender interaction on depressive symptoms indicated that depressive symptoms increased with age but the increase was more pronounced in men than women. This suggests that emotional well-being may be better in men than in women in young-old age, but in very old age steeper increases in depressive symptoms among men first reduce and then reverse the earlier gender difference. These findings suggest that changes in depressive symptoms in old age are age-, pathology-, and mortality-related.

Depressive Symptoms and Age

Consistent with findings from the Florida Retirement Study (Zhang et al., 2009), our results showed an increase in depressive symptoms as individuals get older. Our results advance those reported from the Florida Retirement Study in that we examined trajectories of depressive symptoms as a function of chronological age, rather than time-in-study. This allowed us to address the question of whether depressive symptoms change as individuals get older (rather than with the passage of time regardless of age). Consistent with previous studies (Kessler, Foster, Webster, & House, 1992; Schilling et al., 2013; Zarit et al., 1999; Zhang et al., 2009), our findings suggest that depressive symptoms increase from the young-old to the oldest-old. Thus, our findings are in support of the increasingly less favorable gain-loss dynamic wherein older age is associated with compromised emotional well-being (Baltes & Smith, 2003).

Depressive Symptoms and Pathology

The World Health Organization World Health Survey (Moussavi et al., 2007) examined the self-report of depressive symptoms in individuals with different chronic disorders in a sample of over 240,000 participants from 60 countries. Results showed that individuals with arthritis had a higher one-year prevalence of depressive episode (based on the cut-off score of depressive symptoms in the past 12 months), 4.1%, compared to the average of 3.2%. Specifically, the one-year prevalence of depressive episode in individuals with arthritis ranked second, compared to individuals with angina (4.5%), asthma (3.3%), and diabetes (2.0%). Approximately half of the participants in the present study reported having a current diagnosis of arthritis at some point over the 15 year period. In addition to the high prevalence rate, arthritis is a very painful and disabling health condition (Dexter & Brandt, 1994). Although the present study did not include measures of participants' pain and arthritis severity, our findings point to the importance of

vulnerabilities to low emotional well-being in individuals with arthritis and chronic pain in general (Schmitz, Saile, & Nilges, 1996).

Depressive Symptoms and Mortality

In line with findings from the Florida Retirement Study (Zhang et al., 2009), the observed developmental trajectory of depressive symptoms was associated with an increase in the risk of death. However, the use of chronological age, rather than time-in-study, as the time metric in the present study rendered our results not directly comparable to the Florida Retirement Study. Nonetheless, our findings are consistent with reports from the cognitive domain showing that between-person differences in the level of, and age-related changes in, multiple cognitive functions are associated with mortality (Ghisletta, 2008; Ghisletta et al., 2006). Likewise, past findings revealed that multiple dimensions of emotional well-being are associated with mortality, e.g. life satisfaction, depressive symptoms, and negative affect (Anstey & Luszcz, 2002; Gerstorf et al., 2008; Gerstorf et al., 2010; Schilling, Wahl, & Wiegering, 2012; Zhang et al., 2009). It would be highly instructive if future studies were to examine whether the age-related changes in multiple dimensions of emotional well-being (i.e., cognitive vs. affective components of subjective well-being, and somatic vs. non-somatic depressive symptoms) are differentially associated with mortality (Gana et al., 2013; Schilling, 2006). In terms of clinical implications, individuals reporting more depressive symptoms may be more likely to engage in unhealthy behaviors and have less social support, thus leading to a higher risk of mortality (Giles, Glonek, Luszcz, & Andrews, 2005; Schulz, Martire, Beach, & Scheier, 2000). Given the demographic projections of increases in the number of older and oldest-old adults in particular (Suzman, Willis, & Manton, 1992), the societal burden of rising depressive symptoms in old age is concerning. Our findings suggest that recognition of depressive symptoms in older adults and

early interventions are imperative to enhance the quality of life in advanced old age (Mastel-Smith, McFarlane, Sierpina, Malecha, & Haile, 2007).

Gender and Depressive Symptoms

Gender differences in the level and rate of change in depressive symptoms were the final focus of our study. Consistent with findings from a Danish sample (Barefoot et al., 2001), we found a significant age by gender interaction on depressive symptoms. Specifically, the rate of change in depressive symptoms was steeper in men such that in young-old age, men reported a lower level of depressive symptoms than women. However, the gender difference reduced and then reversed with increasing age, with men reporting higher levels of depressive symptoms than women in very old age. Gender differences in social networking and social support, as well as variations in coping styles may explain the reversed gender gap in depressive symptoms in advanced old age (Aldwin, Spiro, & Park, 2006). It may be that men more than women are likely to use problem-focused coping rather than emotion-focused coping (Tamres, Janicki, & Helgeson, 2002). The changing life circumstances from young-old to oldest-old age may render the use of problem-focused coping less effective in maintaining emotional well-being (Lazarus & Folkman, 1984). For example, chronic health constraints pose difficulties in everyday functioning in old age and may not be readily resolved and may instead be denied. In contrast, the use of emotion-focused coping such as empathy may better enable women to come to terms with the losses that are outside of the control of an older adult and that therefore cannot be fixed using problem-focused coping, such as death of spouse or loss of independence, in advanced old age (Diehl et al., 2014). Thus, our findings point toward a potential source of vulnerability in older men, when life circumstances in advanced old age may call for coping styles that they are less accustomed to using.

Significance of the Current Study

Our findings revealed that both the level of, and changes in, depressive symptoms were associated with risk of death. Importantly, estimates of age-related changes in depressive symptoms from joint modeling take attrition due to mortality into account, thus giving a less biased picture of the development of depressive symptoms in old age (Graham et al., 2011; Rizopoulos, 2012). This is consistent with the possibility that past findings that ignore nonrandom dropout due to mortality may underestimate the age-related declines in life satisfaction (Mroczek & Spiro III, 2005). Our study extended earlier findings of gender differences in depressive symptoms (Barefoot et al., 2001; Nolen-Hoeksema, Larson, & Grayson, 1999). By including old-old and oldest-old adults in our large sample, the age by gender interaction effect indicates that gender gap in depressive symptoms reduced from young-old to old-old and reversed at the extremes of old age.

Limitations and Outlook

The present study is unique in that we use 15-year longitudinal data from a very old sample and recent advances in statistical techniques for longitudinal analysis. However, our findings should be considered in light of several limitations. First, the present study is limited by the lack of clinical assessments of depression, illness burden, and cause of mortality. Previous studies suggest that clinical assessments of severe medical conditions (such as cancer and coronary heart diseases), and causes of death are possibly associated with the age-related and mortality-related processes and shape depressive symptom trajectories in old age (Anstey, Mack, & von Sanden, 2006; Bäckman & MacDonald, 2006; Sliwinski et al., 2006; Small, Fratiglioni, von Strauss, & Bäckman, 2003). Of note though is that the self-reported number of medical conditions also was a significant predictor of mortality. This suggests that self-reports of illness

burden such as the number of medical conditions may be a useful proxy to quantify individuals' health status (Lee, 2000). In addition, a substantial body of literature has examined the association between depressive symptoms and a myriad of medical diagnoses in clinical samples, including macular degeneration, diabetes, cancer, cardiac diseases, and comorbidity of multiple chronic health conditions (Ciechanowski, Katon, & Russo, 2000; Rovner, Casten, Hegel, Leiby, & Tasman, 2007). Future research may further validate our findings by including clinical assessments of illness burden, and biological markers of health, such as stress response and immunological functioning (Franceschi et al., 2000), in the examination of longitudinal development of depressive symptoms.

Second, the use of a heterogeneous sample in terms of age at baseline (64.9-103.5 years) and an extended follow-up period allowed the examination of age-related changes in depressive symptoms from young-old to oldest-old age. However, in contrast to the 11 yearly assessments in the Florida Retirement Study (Zhang et al., 2009), the intervals between the five waves of our longitudinal study were uneven and more widely spaced in later waves. Past findings indicate a curvilinear pattern of age-related changes in depressive symptoms (Clarke et al., 2011) and abrupt changes in life satisfaction and affective well-being at about 4-7 years before death (Gerstorf et al., 2008; Gerstorf et al., 2010; Schilling et al., 2012). It is possible that the more widely spaced intervals in the present study are less than optimal to capture the quadratic effect of age on depressive symptoms. Nevertheless, our findings were similar to that of the Florida Retirement Study, such that no accelerated time-in-study effect, i.e. quadratic effect of time-in-study, in depressive symptoms was observed.

Third, our sample did not include young and middle aged adults. We cannot extrapolate our findings to the earlier stages of human development, nor to these participants' previous

experiences. Thus, our findings are limited in addressing questions regarding the lifespan development of depressive symptoms. For example, our findings cannot address questions of late-life depression that may originate in early adulthood (Blazer & Hybels, 2005; Clarke et al., 2011). Nonetheless, our findings are conceptually in keeping with the lifespan development framework (Baltes et al., 2006). In addition, our results pertain to depressive symptoms and may not be generalizable to age-related changes in the rates of clinical depression. Future studies are needed to examine the lower rates of diagnosed clinical depression in late-life compared to young adults (Blazer & Hybels, 2005).

Fourth, the present study cannot tease apart the cause-and-effect associations between depressive symptoms and changes associated with age, pathology, and mortality. Instead of the integrative approach adopted in the present study, recent research examined the effects of age, pathology, and mortality on depressive symptoms in separate models (Fauth et al., 2014). Results showed that age, pathology, and mortality each explain changes in depressive symptoms, although to varying degrees. Our findings likewise suggest that, even though the increase in the relative risk in mortality is small, the developmental trajectory of depressive symptoms is a function of age-, pathology-, and mortality-related processes. Future research might include a lead/lag effect of pathology to examine the cause-and-effect relationship between pathology and depression.

Conclusion

The present study complements and extends a growing body of research by suggesting that depressive symptoms increase from young-old to oldest-old age and that the age-related trajectory of depressive symptoms is associated with increased likelihood of mortality. These findings converge with results from the literature that late life and its increasingly less favorable

gain-loss dynamic may challenge individuals' well-being (Baltes & Smith, 2003). Subgroups of

oldest-old adults are likely to experience qualitatively different vulnerabilities, such that

individuals of low physical functioning may be predisposed to a higher level of, and more rapid

increase in, depressive symptoms (Schilling et al., 2013). Although some dimensions of

emotional well-being may be maintained or improved through advanced old age, age-related

vulnerabilities such as chronic health conditions may render the implementation of coping and

self-regulation strategies difficult if not impossible, thus leading to the age-related increase in

depressive symptoms (Charles, 2010). Some interventions, such as problem-solving treatment,

may alleviate the effect of chronic health conditions for a short-term (Rovner et al., 2007).

Specifically, evidence showed that problem-solving treatment prevented depressive disorders in

a sample of older adults with recent diagnoses of macular degeneration two months after the

treatment program, but not in the long-term, i.e. six months later (Rovner et al., 2007). Future

studies are needed to evaluate the long-term effect of treatment to alleviate depressive symptoms

in older adults. For example, evidence has shown that volunteering interventions designed to

enhance generativity, such as Experience Corps, have increased physical, cognitive, and social

activities in older adults (Fried et al., 2004). Future research may investigate which types and

aspects of volunteering may promote social and psychological resources to reduce depressive

symptoms in older adults (Borgonovi, 2008; Musick & Wilson, 2003). Furthermore, studies on

life-review intervention may illuminate how to enhance wisdom and reduce depressive

symptoms in old age (Daniels, Boehnlein, & McCallion, 2015). Social policies and aging-

friendly support structures, such as the provision of public transport and access to (ambulatory)

healthcare services for older adults (National Aged Care Alliance, 2007), are needed to target

oldest-old adults as a whole, but also subgroups of oldest-old adults who need support services

most.

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Table 1. Means and Standard Deviations of Depressive Symptoms, and Covariates by Wave and Gender

Measure		Wave 1 (1992) $n = 2,087$ M(SD)	Wave 3 (1994) $n = 1,679$ M(SD)	Wave 6 (2000) $n = 791$ M(SD)	Wave 7 (2003) $n = 487$ M(SD)	Wave 9 (2007) $n = 217$ M(SD)
CES-D	Men	8.02(7.20)	7.82(7.22)	8.61(6.33)	8.04(7.43)	9.47(7.64)
	Women	8.63(7.71)	8.86(7.43)	9.40(6.88)	8.82(7.42)	10.09(6.92)
CES-D $\geq$ 16	Men	14%	13%	14%	15%	25%
	Women	16%	19%	17%	16%	18%
Age (in years)	Men	79.47(6.17)	80.88(6.04)	84.91(5.22)	86.16(4.47)	89.25(3.75)
	Women	77.89(7.07)	79.35(6.84)	83.50(5.80)	84.98(5.04)	87.59(4.10)
Arthritis diagnosis	Men	51%	40%	40%	49%	39%
	Women	58%	50%	53%	59%	61%
Marital status$_a$	Men	70%	64%	57%	57%	54%
	Women	60%	52%	36%	26%	20%
Living arrangement$_b$	Men	95%	91%	84%	90%	86%
	Women	93%	90%	85%	82%	87%
MMSE	Men	26.83(4.02)	27.17(2.77)	27.87(2.50)	21.89(10.09)	23.49(9.00)
	Women	26.92(4.40)	27.52(2.60)	28.20(2.13)	21.69(9.98)	23.70(8.46)
Number of medical conditions	Men	5.33(2.90)	4.02(2.59)	3.82(2.81)	5.10(3.04)	4.09(2.66)
	Women	5.34(3.10)	4.28(2.58)	4.19(2.87)	5.47(3.39)	4.27(2.49)

Difficulties in ADL	Men	.34(1.00)	1.02(1.81)	1.29(2.07)	.88(1.79)	.10(.38)
	Women	.41(1.10)	1.21(1.93)	1.46(2.18)	.91(1.56)	.32(1.22)
% women		49.40	50.86	57.65	62.22	64.98

Note. CES-D = Center for Epidemiologic Studies Depression Scale. MMSE = Mini Mental State Examination. ADL = Activities of daily living.

[a]Marital status is indicated by the percentage of participants who were married or in a defacto relationship.

[b]Living arrangement is indicated by the percentage of participants who were community living.

M = mean; *SD* = Standard deviation.

Table 2. Results of Age-Related Changes and Mortality from Joint Models

	Model 1	Model 2
	Estimate(*SE*)	Estimate(*SE*)
Parameters from the longitudinal sub-model		
Fixed effects		
Intercept, a_{00}	7.77(.32)***	7.76(.32)***
Level 1		
Age$_a$, a_{10}	.11(.02)***	.11(.02)***
Arthritis diagnosis, a_{20}		.55(.18)**
Marital status, a_{30}	-1.57(.19)***	-1.57(.19)***
Living arrangement, a_{40}	.72(.38)	.75(.37)*
MMSE, a_{50}	-.18(.04)***	-.19(.04)***
Medical condition, a_{60}	.14(.04)**	.11(.04)*
Difficulties in ADL, a_{70}	.59(.08)***	.59(.08)***
Level 2		
Gender, a_{01}	2.41(.45)***	2.40(.45)***
Age × Gender, a_{11}	-.14(.03)***	-.14(.03)***
MMSE (BP) $_b$, a_{02}	-.34(.03)***	-.34(.03)***
Medical condition (BP), a_{03}	.73(.04)***	.69(.04)***
Difficulties in ADL (BP), a_{04}	.97(.08)***	.95(.09)***

Random effects$_c$		
Standard deviations		
Intercept	3.52	3.50
Age	.07	.07
Residual	4.71	4.71
Correlation		
Intercept-age	.64	.64
Parameters from the survival sub-model		
Intercept, γ_0	-13.40(.27)***	-13.40(.27)***
Gender, γ_1	-.30(.05)***	-.30(.05)***
Education, γ_2	-.02(.05)	-.02(.05)
Parameters from the joint model		
Association parameter, α	.02(.001)***	.02(.001)***
log(shape)	1.39(.02)***	1.39(.02)***
Goodness of fit		
AIC	39,807	39,808
BIC	39,925	39,932
-2LL	39,765	39,764

Note. SE = Standard error; ADL = activities of daily living; MMSE = Mini Mental State

Examination; AIC = Akaike information criterion; BIC = Bayesian information criterion; -2LL =

-2 × Log Likelihood.

[a]Age is grand-mean centered at 64.90 years. Gender is dummy-coded (Men = -0.5, Women =

0.5). Martial status (Married/defacto = 0.5, others = -0.5) and living arrangement (Community-

living = 0.5, others = -0.5) are dummy-coded. Education is grand-mean centered. MMSE,

medical conditions, and activities of daily living are within-person centered. The between-person

mean (BP) of MMSE, medical conditions, and activities of daily living are entered in the model

as level-2 covariates.

[b]BP = Between-person mean.

[c]The JM library in R does not give the variances and covariances of random effects.

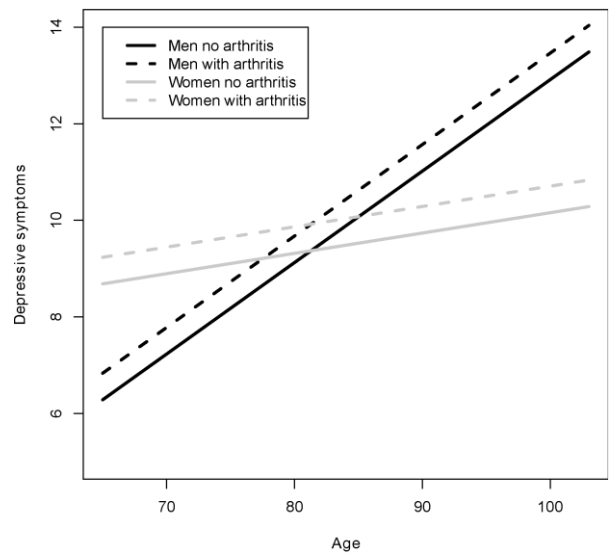***$p < .001$; **$p < .01$; *$p < .05$.

Figure Caption

Figure 1. Figures 1a shows the significant gender by age interaction effect, such that the gender difference in depressive symptoms reduced from young-old to old-old, then reversed from the oldest-old. *Figure 1b* shows that individuals with arthritis reported a higher level of depressive symptoms.

Results from Joint Model: Interaction Plot for Men and Women
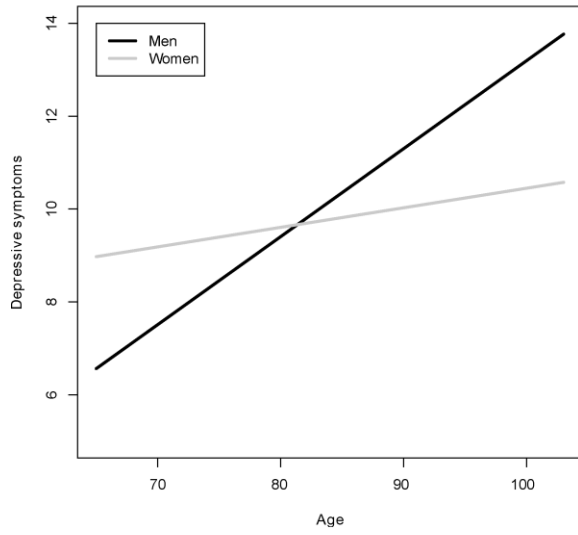
Results from Joint Model:
Interaction Plot for Men and Women with and without Arthritis

(a)   (b)