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Widowhood and mortality among the elderly: The modifying role of neighborhood concentration of widowed individuals[⋆]

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Abstract

The effect of death of a spouse on the mortality of the survivor (the "widowhood effect") is well-established. We investigated how the effect of widowhood on mortality depends on the neighborhood concentration of widowed individuals in the United States. We developed a large, nationally representative, and longitudinal dataset from Medicare claims and other data sources characterizing 200,000 elderly couples, with nine years of follow-up (1993–2002), and estimated multilevel grouped discrete-time hazard models. In neighborhoods with a low concentration of widowed individuals, widowhood increased the odds of death for men by 22% and for women by 17%, compared to 17% for men, and 15% for women in neighborhoods with a high concentration of widowed individuals. Our findings suggest that neighborhood structural contexts – that provide opportunities for interacting with others and favoring new social engagements – could be potential modifiers of the widowhood effects and as such requires more systematic consideration in future research of widowhood effects on well-being and mortality.

Keywords

Bereavement; Mortality; Neighborhood; Multilevel discrete-time hazard analysis; Widowhood effect; Gender; USA

Introduction

The "widowhood effect," describing the increased probability of death among the recently bereaved is one of the best-documented effects of social relationships on health (Schaefer, Quesenberry, & Wi, 1995). The widowhood effect has been found in bereaved men and women of all ages around the world, using cross-sectional and longitudinal data, with and without covariate controls, and diverse statistical methodologies (Helsing, Comstock, & Szklo, 1982; Hu & Goldman, 1990; Kraus & Lilienfeld, 1959; Lillard & Waite, 1995; Parkes, Benjamin, & Fitzgerald, 1969). Recent longitudinal studies put the long-term excess risk of death associated with widowhood compared to marriage at around 15%, net of controls. Estimates for the short-term effect during the first few months following bereavement range from 50 to 90% (Elwert

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& Christakis, 2006; Martikainen & Valkonen, 1996b; Schaefer et al., 1995). Researchers typically attribute the widowhood effect to the difference between the salubrious qualities of marriage and the detrimental consequences of widowhood (Elwert & Christakis, 2006). While married spouses benefit from emotional support, spousal promotion of healthy behavior (Umberson, 1987, 1992), economic stability (Lillard & Waite, 1995; Trovato, 1991), and possibly superior health care utilization (Iwashyna & Christakis, 2003; Umberson, Wortman, & Kessler, 1992), bereaved individuals typically lose these benefits. The strongest effect of widowhood are found soon after bereavement (Elwert & Christakis, 2006; Martikainen & Valkonen, 1996a), possibly because of the imposition of burdens such as coping with the stress of watching and caring for a partner who is dying (Christakis & Allison, 2006), coming to terms with the emotional burden of bereavement, adjusting to new social roles and daily routines, and developing functional substitutes for the health benefits of marriage.

A fundamental question that remains unexplored in this area of research, however, is whether the observed widowhood effect varies according to particular contextual circumstances. While recent research has begun to document individual-level effect heterogeneity in the widowhood effect, for example with respect to race (Elwert & Christakis, 2006) and cause of death (Elwert & Christakis, in press; Johnson, Backlund, Sorlie, & Loveless, 2000), we are not aware of any research to investigate differences in the widowhood effect according to the environment in which individuals experience bereavement. Yet, contextual factors are widely recognized to be relevant to differences in mortality (Chen et al., 2006; Krieger, Chen, Waterman, Rehkopf, & Subramanian, 2005; O'Campo, 2003; Pickett & Pearl, 2001; Subramanian, Chen, Rehkopf, Waterman, & Krieger, 2005; Wen & Christakis, 2005). Given that the postulated mechanisms linking widowhood and mortality are primarily social, it seems reasonable to anticipate that the broader contextual circumstances of bereaved individuals may buffer or intensify the social processes that make widowhood a strong risk factor for mortality in the first place. This study therefore investigated the effect heterogeneity in the widowhood effect as a function of the residential context of the surviving spouse. Specifically, we examined an aspect of the social environment that may be particularly relevant for widowed men and women as a way of providing collective social support, measured through neighborhood concentration of widowed individuals (men and/or women), and viewed as a positive attribute of social environment for widowed residents.

Neighborhoods, we postulate, are likely to serve as active *milieu* for facilitating social and economic ties for the elderly widowed that tend to become important to counter social marginalization and isolation particularly soon after bereavement (Adams, 1985a, 1985b). Prior evidence suggests the importance of neighbors in late life (Lamme, Dykstra, & van Groenou, 1996). It is plausible that an important mechanism through which neighborhoods might differentially affect widowed individuals' risk of mortality (or quality of life more generally) is by providing a recruiting ground for new social contacts (Smith & Christakis, 2007). Consequently, differences in the structural context of the neighborhoods could modify the significance of the change in status brought about by the death of a spouse – by providing opportunities for, or constraining the, formation and maintenance of friendships and other social ties.

We therefore suppose that neighborhoods provide an environment that may buffer the effect of individual widowhood. One such aspect, we hypothesize, could be the presence of other widowed individuals (widows and/or widowers) in the neighborhood. While being widowed clearly represents a substantial individual disadvantage, living amongst other widowed individuals may partially ameliorate this individual burden. Individual experience of being widowed, *within the context of the prevalence rates of widowhood in the community*, has been shown to shape the level of friendships and participations among the elderly (Blau, 1961). To the extent that neighborhood ties and friendships are formed on the basis of similarities between individuals, one can expect a widowed individual living in a neighborhood with low prevalence of widowed individuals to be atypical with respect to the neighborhood norm and to run the risk of being socially isolated and marginalized. On the other hand presence of other widowed individuals is likely to provide the surviving individual with an opportunity to share the common experiences of bereavement, facilitate collective coping strategies, and possibly, in the long run, to find replacements for their spouses. The concentration of widowed individuals is also likely to increase the supply of infrastructure and support services that are relevant for elderly widowed individuals, such as availability of support services for the elderly.

We are not aware of any published study that has examined the role of neighborhood concentration of widowed individuals in attenuating and/or modifying the relationship between widowhood and mortality. Consequently, the study focused on the following specific questions:

1. Does the effect of widowhood on mortality persist even after accounting for neighborhood concentration of widowed individuals?
2. Is there an effect of neighborhood concentration of widowed individuals on individual mortality, over and above the individual-level widowhood effect on mortality?
3. Does living in an area with a higher fraction of widowed individuals modify the effect of widowhood on mortality?

Methods

Data

We use unencrypted Medicare claims data to assemble a large, nationally representative, and longitudinal cohort of married elderly couples in the United States. Medicare databases are uniquely suited for research on contextual variation in the widowhood effect as they provide prospective information for over 96% of elderly Americans (whether they used health care or not) with daily mortality follow-up (Hatten, 1980), permit (with some constraints) the identification of both spouses of elderly married couples (Iwashyna, Zhang, Lauderdale, & Christakis, 1998), contain detailed physician-ascertained medical information to control for baseline differences in morbidity, and identify the place of residence of all participants, thus permitting extensive record linkage for contextual features of the residential environment. In the first step of data development, Medicare beneficiaries older than 65 years on January 1, 1993, in the Denominator File were identified. Among the 32,180,588 elderly in this file, we estimate, based on Census statistics, that there are 6.6 million currently married heterosexual couples where both members are 65 years and older, of which we detected 5,496,444 (Iwashyna, Brennan, Zhang, & Christakis, 2002; Iwashyna et al., 1998). Since individuals typically enter Medicare at age 65 years, we restricted the analysis to couples where both partners were older than 67 years at baseline in order to guarantee the availability of a full two years of health background controls for the entire sample. We also restricted our sample to those less than or equal to 98 years old. Due to idiosyncrasies in Medicare race coding rules, we restricted the analysis to non-Hispanic White or Black couples. Briefly, it has been suggested that Medicare data are well-suited to support the identification of non-Hispanic Black and White beneficiaries, but not the identification of other races or ethnic groups (Arday, Arday, Monroe, & Zhang, 2000; Elwert & Christakis, 2006; Lauderdale & Goldberg, 1996). Lastly, since the widowhood effect should hinge on marital co-residence, we exclude couples with discordant ZIP codes of husband and wife. From the remaining pool of elderly married couples after sample restrictions, we analyze a simple random sample of 200,000 couples to satisfy computer hardware and software constraints.

Using the Vital Status File, we obtained daily mortality follow-up through January 1, 2002 (Elwert & Christakis, 2006). From the death dates of both members of each couple, we derived the outcome (time to death or censoring since January 1, 1993) and the individual independent variable of interest (widowhood). We censored all surviving couples at the end of follow-up on January 1, 2002. There was no loss to follow-up.

From the Medicare Provider Analysis Review (Med-PAR) files, we extracted detailed health histories to control for differences in baseline morbidity in 1991–1992 for each individual. Following previous work, we summarized the chronic disease burden at baseline by computing Charlson co-morbidity scores (Charlson, Pompei, Ales, & MacKenzie, 1987) from hospitalization records separately for each spouse, and categorized them into low, moderate, and severe (Charlson scores of 0, 1, and 2 or higher, respectively) (Zhang, Iwashyna, & Christakis, 1999). We also included counts of the number of days each partner had spent in the hospital in 1991 and 1992. Both these variables were included as confounders, since they may be prior common causes to the relationship between widowhood and mortality (Christakis & Allison, 2006), and to the relationship between neighborhood factors and mortality.

We derived race classifications for both spouses from the race and ethnicity variable in the Vital Status file. This variable was populated from the Social Security Administration's Master Beneficiary Record (MBR) and has been verified and updated against the self-reported race classifications on beneficiaries' applications for (replacement) social security cards by the Center for Medicare and Medicaid Services (Arday et al., 2000).

The Denominator file provides additional individual-level demographic information (i.e., age and sex) from Social Security records and information on the couple's area of residence (ZIP code). Following prior practice, we use the dual eligibility for Medicare and Medicaid services of either spouse in 1993 as a proxy for couple's poverty status at baseline (CMS, 2005; Clark & Hulbert, 1998; Pope, Adamache, Walsh, & Khandker, 1998). We used ZIP codes as one realization of an individuals' neighborhood context. The desirable population size of ZIP-code areas, and their prior use in studies of geography and health, makes ZIP codes one useful realization of an individuals' context. However, we recognize the limitation of using administrative boundaries for conceptualizing neighborhoods. ZIP-code boundaries often represent well-defined local residential areas recognized as such by their residents. Data limitations prohibited geo-coding individual observations to other levels of aggregation, such as Census tracts and block groups that have also been shown to be important geographic levels for a variety of health outcomes (Krieger et al., 2005; Subramanian, Chen, Rehkopf, Waterman, & Krieger, 2006). To the individual data, we merged ZIP-code-level contextual information from the 1990 decennial U.S. Census related to (1) percent population who were widowed; (2) percent male population who were widowed; and (3) percent female population who were widowed. We additionally included percent population living in poverty as an area-level covariate in our models. For the analysis, we included the ZIP-code variables as dichotomous variables based on values below and above the median for each of the variables. Analyses based on continuous specifications did not yield meaningfully different results (results not shown).

Statistical analysis

On January 1, 1993 we observed 400,000 individuals in 200,000 married couples, followed them until January 1, 2002, and ascertained information on two events: whether the individual died and whether the individual lost his or her spouse during the same period. The outcome, mortality, and the individual predictor, widowhood, were observed on a daily basis. Widowhood entered the analysis as a time-varying predictor. Given our objective of examining the influence of ZIP-code-level factors on the relationship between widowhood and mortality, we created a multilevel data structure of 200,000 married couples nested within 23,272 ZIP codes nested within 50 states, and the District of Columbia, thereby necessitating a multilevel modeling strategy (Goldstein, 2003; Raudenbush & Bryk, 2002). We adopted a multilevel grouped discrete-time hazard analysis for this study. Amongst other advantages, a discrete-time hazard modeling approach allows us to exploit the flexibility of discrete response data modeling, which was useful given the three-level structure of the data (Goldstein, Browne, & Rasbash, 2002; Steele, 2003). We briefly describe the discrete-time hazard model (Allison, 1982; Singer & Willet, 1993), and then extend it to include the random effects and cross-level interactions (Callens & Croux, 2005; Hedekar, Siddiqui, & Hu, 2000; Steele, 2003). We estimated separate models for husbands and wives.

Specifically, we sequentially developed models from simple to complex ones, thus allowing an assessment of the contribution of this analysis to existing knowledge on the links between widowhood and mortality. We started by estimating a model that essentially modeled mortality as a function of time elapsed and observed characteristics of individuals (e.g., age, health status at baseline, widowhood). Second, we allowed for unknown characteristics of individuals that might cause variation in the probability of death (individual level random effects). Third, we allowed for random effects at the levels of ZIP-code and state of residence. Fourth, we included characteristics of ZIP codes that might independently influence risk of death (i.e., a measure of poverty and proportion widowed); and finally, we considered a cross-level interaction between individual widowhood and proportion widowed in the area (controlling for the other individual variables and ZIP-code poverty). In the following paragraphs, we provide a general methodological outline and description of the statistical models estimated for this study.

Discrete-time hazard analysis

Data were arranged in person-year format separately for husbands and wives. In a sample of 200,000 couples, husbands contributed 1,417,825 person-years of data, and wives contributed 1,648,176 person-years (since women live longer). Hardware limitations imposed a direct trade off between data coarseness (length of time intervals) and sample size (number of individuals). Experiments with monthly intervals yielded similar point estimates but lower statistical efficiency, thus suggesting our present person-year approach. Widowhood is coded equal to 1 starting with the year of widowhood until proband's death or censoring.

Time is measured as a positive discrete random variable T_i, and we observe T_i for n individuals, and denote their realizations by t_i for $1 \leq i \leq n$. At time t, either an event occurs or the observation is censored by the end of follow-up (non-informative censoring). For each individual i, we include a vector of time-constant predictors, $\mathrm{x_i}$ (e.g., race) and time-varying widowhood predictor, w_{ti}.

The discrete-time hazard function p_{ti} is then defined as the conditional probability that at time t an individual i is dead, given that the individual did not die before t:

$$p_{ti}=\Pr(T_i=t|T_i \geq t) \tag{1}$$

One common specification for the dependence of the hazard rate on time t and set of time constant and time varying explanatory variables (x_i and w_{ti}) is provided by the logistic regression function (2):

$$p_{ti}=\frac{1}{[1+\exp(-(\alpha_t+\beta' x_i+\beta^w w_{ti}))]} \tag{2}$$

or, re-writing this in the logit or log-odds form, gives:

$$\text{logit}(p_{ti})=\log\left[\frac{p_{ti}}{(1-p_{ti})}\right]=\alpha_t+\beta' x_i+\beta^w w_{ti} \tag{3}$$

In specification (3), α_t is a set of constants, one for each discrete-time point, and represents the logit of the baseline hazard function. The parameter vector β' represents the regression coefficients associated with x_i, and the parameter β^w represents the regression coefficient associated with w_{ti}. The effects of predictors ($\beta' x_i$, and $\beta^w w_{ti}$) are constant over time, i.e., we assumed proportional hazards (or, strictly speaking, proportional odds) over time. Since we used years to define our discrete time (instead of days), we allowed for the different lengths of exposure days within the year intervals for survival as well as for widowhood. We denoted these varying day-exposure within a year by n_{ti} which is the exposure time in the grouped interval t for individual i. With this, the response variable was not a binary variable, but a proportion. More formally, instead of using y_{ij} as the binary response (1 or 0), we used y^*_{ti}, which is $y^*_{ti}=y_{ti}/n_{ti}$, with n_{ti} being the denominator (or offset) for this proportion that accounts for the differential length of exposure with the year intervals.

Discrete-time hazard analysis with unobserved heterogeneity

Model (3) describes the basic discrete-time hazard function model, but it does not account for two important features. It is reasonable to anticipate that some individuals will be more at risk of mortality than others, and it is unlikely that the reasons for this variability in the hazard will be fully captured by observed covariates. In other words, Model (3) may suffer from unobserved heterogeneity or frailty. Importantly, if there are individual-specific unobserved factors that affect the hazard, the observed form of the hazard function at the aggregate population level will tend to be different from those at the individual level. Even if the hazards of individuals in a population are constant over time, the aggregate population hazard may be time-dependent, and typically decreasing. This may be explained by a selection effect operating on individuals. If unobserved heterogeneity is incorrectly ignored, the magnitude of regression coefficients will be underestimated. In order to account for unobserved heterogeneity, we introduced a random effect for each individual that represents individual-specific unobservables as:

$$\begin{aligned}&\text{logit}(p_{ti})=\log\left[\tfrac{p_{ti}}{(1-p_{ti})}\right]\\&=\alpha_t+\beta' x_i+\beta^w w_{ti}\\&+e_i, \quad \text{where } e_i \sim N(0,\sigma_e^2)\end{aligned} \tag{4}$$

where, σ_e^2 represents frailty. We note that in the model with frailty, exp(β) represents the odds ratio, when the random effect is held constant, i.e., if we are comparing two hypothetical individuals with the same random effect value. Thus exp(β) is the individual-specific effect of x.

Multilevel discrete-time hazard analysis with unobserved heterogeneity

Given our explicit interest in modeling the effects of ZIP-code-level variables on the relationship between individual widowhood and mortality, we extended Model (4) to include random effects associated with ZIP codes and states. The basic principles and relevance of multilevel models for analyzing the influence of contextual factors has been well-described before (Blakely & Subramanian, 2006;Subramanian, 2004;Subramanian, Jones, & Duncan, 2003), and here we present the two kinds of models that we calibrated. Models (5) and (6) evaluate whether introducing ZIP-code-level variables alters the individual effect of

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widowhood on mortality. Thus, the binary response, dead or not, at time *t* for individual *i* living in ZIP code *j* in state *k* was formulated as:

$$\begin{aligned}&\text{logit}(p_{tijk})=\log\left[\frac{p_{tijk}}{(1-p_{tijk})}\right]\\&=\alpha_t+\beta' x_{ijk}+\beta^{w} w_{tijk}+v_k+u_{jk}+e_{ijk},\end{aligned} \tag{5}$$

where $e_{ijk} \sim N(0,\sigma_e^2);u_{jk} \sim N(0,\sigma_u^2);v_k \sim N(0,\sigma_v^2)$; and Cov$[v_k,u_{jk},e_{ijk}] = 0$.

The equation consists of a fixed part, $\alpha_t + \beta' x_{ijk} + \beta^{w} w_{tijk}$, and random effects attributable to individuals (e_{ijk}), ZIP codes (u_{jk}), and states (v_k). The parameter β^{w} estimates the differential in the log odds in mortality for the time-varying predictor, widowhood, w_{tijk}, without adjusting for any fixed-effect of ZIP-code-level variables (i.e., poverty or fraction widowed individuals), but adjusted for baseline risk factors ($\beta' x_{ijk}$) and base-line hazard function (α_t), specified as a dummy variable for the different years, with the reference being 1993. Assuming an independent and identical distribution, the random effects can be summarized as σ_e^2 (individual), σ_u^2 (ZIP code), and σ_v^2 (states). These variance components quantify the heterogeneity in the mortality at each level, with the latter two being suggestive of the independent importance of geographic contexts of ZIP codes and states for mortality.

Next, we introduce ZIP-code-level variables to the fixed part of Model (5), in order to ascertain if conditioning on ZIP-code-level factors changes the effect of widowhood on mortality.

$$\begin{aligned}&\text{logit}(p_{tijk})=\log\left[\frac{p_{tijk}}{(1-p_{tijk})}\right]\\&=\alpha_t+\beta' x_{ijk}+\beta^{w} w_{tijk}+\beta^{z} z_{jk}+v_k\\&+u_{jk}+e_{ijk}\end{aligned} \tag{6}$$

where the parameter β^{z} estimates the change in the log odds of mortality of living in a ZIP code where concentration of widowed individuals was above median (z_{jk}). The parameter β^{w} now estimates the differential in the log odds in mortality for the time-varying predictor, widowhood, w_{tijk}, adjusting for any fixed-effect of the ZIP-code-level variables (e.g., fraction widows/widowers(s)). Each of the ZIP-code-level variables was considered separately.

Model (6) was then extended to introduce a “cross-level” interaction between ZIP-code-level factors and individual widowhood as:

$$\begin{aligned}&\text{logit}(p_{tijk})=\log\left[\frac{p_{tijk}}{(1-p_{tijk})}\right]\\&=\alpha_t+\beta' x_{ijk}+\beta^{w} w_{tijk}+\beta^{z} z_{jk}\\&+\beta^{wz}(w_{tijk} \times z_{jk})+v_k+u_{jk}+e_{ijk}\end{aligned} \tag{7}$$

where, the new parameter, β^{wz}, associated with an interaction variable ($w_{tijk} \times z_{jk}$), enables us to evaluate whether the effect of widowhood is contingent on the neighborhood characteristics associated with ZIP-code fraction of widowed individuals. Each of the cross-level interaction between ZIP-code-level variables and individual widowhood was considered separately.

Results provided in Tables 2 and 3 are based on estimating Models (5) and (6); and results provided in Table 4 are based on Model (7). All estimates are quasi-likelihood-based with a Taylor linearization procedure, as implemented within the software *MLwiN* 2.02 (Goldstein &

Rasbash, 1996;Rasbash, Steele, Browne, & Prosser, 2004). Models were separately estimated for the samples of husbands and wives.

Results

Table 1 describes the attributes of the cohort of 200,000 couples at the individual-level and the ZIP-code level. This did not differ from the eligible sample. Over the study period, 52.2% of husbands and 32.6% of wives died.

Table 2 shows the results for Models (5) and (6). Wife's death increases the odds of husband's death by 18% (95% CI 1.16–1.20), and husband's death increases the odds of wife's death by 16% (95% CI 1.14–1.18), net of individual-level and couple-level controls and three levels of random effects (Model (5)). This replicates previous estimates of the widowhood effect using survival models, and as such validates our discrete-time hazard modeling strategy. Controlling for ZIP-code-level fixed effects for neighborhood prevalence of widowed individuals or poverty does not change the estimated widowhood effect for men or for women (Model (6)).

Neighborhood-level fraction of widowed individuals – whether measured in terms of total or only widowers or only widows – does not affect the odds of death for husbands (Table 3, Model (6)). However, the mortality of wives decreased in neighborhoods where the fraction of widowed individuals was above the median (OR 0.98, 95% CI 0.96–0.99). This association appears to be entirely due to the concentration of female widows in the neighborhood (OR 0.97, 95% CI 0.96–0.99), and not to the concentration of male widowers (OR 1.00, 95% CI 0.98–1.02). There was a positive association between neighborhood poverty and mortality. For men, living in a high-poverty neighborhood increases the odds of death by 6% (95% CI 1.04–1.07), and for women it increases the odds of death by 4% (95% CI 1.02–1.06), independent of their widowhood status (results not shown in tables).

Table 4 presents the results for the effect of widowhood on mortality from Model (7), now including the cross-level interaction between the neighborhood concentration of widowed individuals and individual-level widowhood for men and women. This analysis investigates whether the widowhood effect depends in any material way on the presence of other widowed individuals in the area. We find that in neighborhoods with a low concentration of widowed individuals, widowhood increases the odds of death for men by 22% (95% CI 1.18–1.25). In neighborhoods with a high concentration of widowed individuals, widowhood increases the odds of death for men by 17% (95% CI 1.13–1.19). These results are the same whether we measure the neighborhood concentration of widowed individuals by the total share of widowed individuals, or by the share of widowed men or widowed women in the neighborhood. The presence of other widowed individuals in the neighborhood appears to protect men to a certain degree from the detrimental effect of losing their wives.

For women, in neighborhoods with a low concentration of widowed individuals, widowhood increases the odds of death by 17% (95% CI 1.14–1.20). In neighborhoods with a high concentration of widowed individuals, widowhood increases the odds of death for women by 15% (95% CI 1.12–1.19). The results do not vary substantially whether we measure the neighborhood concentration of widowed individuals by the total share of widowed individuals, or by the share of widowed men or widowed women in the neighborhood. As in the case of men before, the neighborhood concentration of widowed individuals appears to attenuate the detrimental effect of widowhood on mortality for women, although the difference appears somewhat smaller.

Discussion

This study, for the first time, investigated the extent to which the individual-level relationship between widowhood and mortality depends on characteristics of respondent's neighborhood of residence, using a unique and large longitudinal sample of elderly married couples throughout the United States. We report three main findings. First, conditioning on neighborhood observables and neighborhood random effect did not alter the individual-level widowhood effect on mortality, and this was true for both men and women. The widowhood effect persisted even after adjusting for neighborhood poverty, and baseline individual-level covariates (including health conditions). Second, we observed an independent effect of neighborhood concentration of widowed individuals, and especially widows, on the risk of mortality for women, such that living in neighborhoods with high concentration of widows decreased the risk of mortality for both widowed and married women. Finally, we find evidence for effect modification in the widowhood effect by neighborhood level characteristics, specifically a protective effect of living in a neighborhood with a high concentration of widowed individuals for widowed men and women: living in neighborhoods with high concentrations of widowed individuals seems to marginally reduce the mortality risk associated with widowhood.

There are several conceivable mechanisms through which neighborhood concentration of widow/er(s) might modify the widowhood–mortality relationship. Spouses are perhaps the single most important members of an individual's social network, and widowhood represents a loss of a major source of support necessitating changes in the extent and nature of the social activities among widowed individuals. Specifically, widowhood brings about an accompanying need for someone else to fulfill the tasks (personal as well as social) that the spouse once otherwise performed. The idea of "social network substitution", which reflects the need for widowed individuals to turn to existing social network members or new social ties to provide the social support and companionship once provided by the spouse, has been considered before (Zettel & Rook, 2004). Indeed, some form of social network substitution is considered to be critical for the recovery process after bereavement (Zettel & Rook, 2004). Within the context of our study that focuses on the potential role of neighborhoods, substitution can involve the formation or renewal of relationships outside of family and relatives. Widowed individuals might renew or forge friendships with others, particularly those who also have experienced bereavement, who in turn could partially replace the missing support and companionship (Morgan, Neal, & Carder, 1997). Such substitution has been shown to compensate – for the support previously provided by the spouse by contributing to psychological well-being of the bereaved individual (Lang & Carstensen, 1994; Rook, Sorkin, & Zettel, 2004; Rook & Schuster, 1996).

Meanwhile, old age, due to declining physical mobility among the elderly, is also typically marked by a compression in life activities. Neighborhoods, we postulate, are likely to serve as active *milieu* for facilitating social and economic ties for the elderly widowed that tend to become important to counter social marginalization and isolation particularly soon after bereavement (Adams, 1985a, 1985b). There is prior evidence that suggests the importance of neighbors in late life (Lamme et al., 1996). It is plausible that a key mechanism through which neighborhoods are likely to differentially affect widowed individuals' quality of life or risk of mortality, is by providing a recruiting ground for new social contacts. Consequently, differences in the structural context of neighborhoods could modify the significance of the change in status resulting from bereavement.

Specifically, widowhood, within the context of the prevalence rates of widowhood in the community, has been suggested to shape the level of friendship and participation among the elderly (Blau, 1961). To the extent that neighborhood ties and friendships are formed on the basis of similarities between individuals, a widowed individual living in a neighborhood with low prevalence of widowed individuals will be atypical with respect to the neighborhood norm. For instance, social events in neighborhoods with low prevalence of widowed individuals are likely to be dominated by married couples, both in terms of sheer visibility as well as in terms of the content of discussions and social activities. Conversely, a widowed individual in a neighborhood with high prevalence of widowed individuals is no longer unusual, and one could anticipate a higher degree of integration of the widowed individual with his or her neighbors, thereby facilitating social participation. Indeed, our findings suggest that in neighborhoods where more individuals are widowed, the effect of individual widowhood is somewhat attenuated.

The findings presented in this study need to be considered alongside certain caveats. First, while our models control for individual-level poverty, data limitations prohibited us from considering additional socioeconomic controls (e.g., income, wealth, education) at the individual level, all of which are likely to influence mortality and could confound both the relationship between widowhood and mortality as well as the cross-level interaction between widowhood, neighborhood concentration of widowed individuals and mortality. This limitation is partially offset by relatively stronger set of controls for morbidity conditions. To the degree that the confounding effect of these omitted variables is not mediated by our measures of baseline health, which substantially exceed the medical controls of other work on the widowhood effect, our results may thus be biased. Without denying the importance of omitted variable bias, we submit, however, that our results are remarkably robust to the introduction of additional covariates beyond age, including to the introduction of controls for health. This robustness of the widowhood effect has also been remarked upon repeatedly in previous research (Elwert & Christakis, 2006; Martikainen & Valkonen, 1996a; Schaefer et al., 1995), suggesting the effect modification due to neighborhood concentration of widowed individuals is less likely to be spurious.

Second, data limitations obliged us to conceptualize ZIP code as the realization of neighborhood context, and as such we were unable to consider more local geographies (e.g., block groups or Census tracts). At the same time, recent studies have suggested that ZIP-code-level variables (which are more easily and routinely collected), recovered estimates that were close to those observed at smaller levels of aggregation, such as Census tracts (Thomas, Eberly, Davey Smith, & Neaton, 2006). Third, the covariate information available at the study, such as prior health condition, was available only for baseline and was not time-varying. However, it is likely that worsening health conditions over time is more likely to be mediator rather than a confounder of the relationship between widowhood and mortality. Fourth, another data limitation pertains to the lack of information on the quality of the marriage (both preceding and during the course of the study period), and the length of the marriage prior to the study period. Both are likely to be confounders of the observed relationship between individual widowhood and mortality. Fifth, we assume that subjects were residents of the ZIP code where they resided when the study began, and no mobility to other ZIP code occurred. While it is possible that individuals move to a different ZIP code during follow-up, residential mobility in old age is typically relatively limited (Claude, 2002).

Conclusions

Some 44% of women and 14% of men aged 65 years and older are widowed (U.S. Census Bureau, 2007). Understanding how widowed individuals might possibly compensate for the loss of the spouse and exploring new links therefore takes on special significance in view of the non-trivial prevalence of widowhood. In recent years, there has been a substantial increase in theorizing regarding neighborhoods as determinants of health outcomes (Kawachi & Berkman, 2003; Kawachi & Subramanian, 2007; Sampson, 2003; Subramanian, Kubzansky, Berkman, Fay, & Kawachi, 2006), along with substantial empirical research (Diez Roux, 2001; O'Campo, 2003); yet there has not been much conceptual or empirical work looking at ways that neighborhoods modify the effects of individual risk factors. Rather, the focus has thus far been on estimating the main effect of neighborhood factors on health outcomes, including mortality. Similar research trends dominate the field of research on the health consequences of widowhood. By introducing a neighborhood or collective perspective to the idea of widowhood effects, this study highlights the need to consider relationships with neighbors, friends, and acquaintances established or renewed after the death of the spouse. It suggests that neighborhood structural context – that provides opportunities for interacting with others and favoring new social engagements – could be a potential modifier of the widowhood effects and as such requires more systematic consideration in future research of widowhood effects on well-being and mortality. An examination of how far social exposures (such as widowhood) vary across individuals and across different contextual settings, such as neighborhoods, is critical for improving our understanding of the specific pathways, through which social exposures influence health. This study presents new evidence of contextual variability in the effect of widowhood on mortality, showing that the widowhood effect may depend in part on wider social contexts.

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References

Adams RG. Emotional closeness and physical distance between friends: implications for elderly women living in age-segregated and age-integrated settings. International Journal of Aging and Human Development 1985a;22(1):55–76. [PubMed: 3830916]

Adams RG. People would talk: normative barriers to cross-sex friendships for elderly women. Gerontologist 1985b;25(6):605–611. [PubMed: 4085874]

Allison PD. Discrete-time methods for the analysis of event histories. Sociological Methodology 1982;13:61–98.

Arday SL, Arday DR, Monroe S, Zhang J. HCFA's racial and ethnic data: current accuracy and recent improvements. Health Care Finance Review 2000;21(4):107–116.

Blakely, T.; Subramanian, SV. Multilevel studies. In: Oakes, JM.; Kaufman, JS., editors. Methods in social epidemiology. San Francisco: Jossey-Bass; 2006. p. 316-340.

Blau ZS. Structural constraints on friendships in old age. American Sociological Review 1961;26(3): 429–439.

Callens M, Croux C. The impact of education on third births. A multilevel discrete-time hazard analysis. Journal of Applied Statistics 2005;32(10):1035–1050.

Centers for Medicare and Medicaid Services (CMS). Overview of Medicaid/Medical dual eligibility. Baltimore, MD: Centers for Medicare and Medicaid Services, U.S. Department of Health and Human Services; 2005.

Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. Journal of Chronic Diseases 1987;40(5):373–383. [PubMed: 3558716]

Chen JT, Rehkopf DH, Waterman PD, et al. Mapping and measuring social disparities in premature mortality: the impact of census tract poverty within and across Boston neighborhoods, 1999–2001. Journal of Urban Health 2006;83(6):1063–1084. [PubMed: 17001522]

Christakis NA, Allison PD. Mortality after the hospitalization of a spouse. New England Journal of Medicine 2006;354(7):719–730. [PubMed: 16481639]

Clark WD, Hulbert MM. Research issues: dually eligible Medicare and Medicaid beneficiaries, challenges and opportunities. Health Care Finance Review 1998;20(2):1–10.

Claude S. Ever-more rooted Americans. City & Community 2002;1(2):177–198.

Diez Roux AV. Investigating neighborhood and area effects on health. American Journal of Public Health 2001;91(11):1783–1789. [PubMed: 11684601]

Elwert F, Christakis NA. Widowhood and race. American Sociological Review 2006;71(1):16–41.

Elwert F, Christakis NA. Variation in the effect of widowhood on mortality by the causes of death of both spouses. American Journal of Public Health. in press

Goldstein, H. Multilevel statistical models. London: Arnold; 2003.

Goldstein H, Browne W, Rasbash J. Multilevel modelling of medical data. Statistics and Medicine 2002;21(21):3291–3315.

Goldstein H, Rasbash J. Improved approximations for multilevel models with binary responses. Journal of the Royal Statistical Society A 1996;159:505–513.

Hatten J. Medicare's common denominator: the covered population. Health Care Finance Review 1980;2 (2):53–64.

Hedekar D, Siddiqui O, Hu FB. Random-effects regression analysis of correlated grouped-time survival data. Statistical Methods in Medical Research 2000;9:161–179. [PubMed: 10946432]

Helsing KJ, Comstock GW, Szklo M. Causes of death in a widowed population. American Journal of Epidemiology 1982;116(3):524–532. [PubMed: 7124718]

Hu YR, Goldman N. Mortality differentials by marital status: an international comparison. Demography 1990;27(2):233–250. [PubMed: 2332088]

Iwashyna TJ, Brennan G, Zhang JX, Christakis NA. Finding married couples in Medicare claims data. Health Services and Outcomes Research Methodology 2002;3(1):75–86.

Iwashyna TJ, Christakis NA. Marriage, widowhood, and health-care use. Social Science & Medicine 2003;57(11):2137–2147. [PubMed: 14512244]

Iwashyna TJ, Zhang JX, Lauderdale DS, Christakis NA. A methodology for identifying married couples in Medicare data: mortality, morbidity, and health care use among the married elderly. Demography 1998;35(4):413–419. [PubMed: 9850466]

Johnson NJ, Backlund E, Sorlie PD, Loveless CA. Marital status and mortality: the national longitudinal mortality study. Annals of Epidemiology 2000;10(4):224–238. [PubMed: 10854957]

Kawachi, I.; Berkman, LF. Neighborhoods and health. New York: Oxford University Press; 2003.

Kawachi I, Subramanian SV. Neighborhood influences on health. Journal of Epidemiology and Community Health 2007;61:3–4. [PubMed: 17183006]

Kraus AS, Lilienfeld AM. Some epidemiologic aspects of the high mortality rate in the young widowed group. Journal of Chronic Diseases 1959;10:207–217. [PubMed: 14411769]

Krieger N, Chen JT, Waterman PD, Rehkopf DH, Subramanian SV. Painting a truer picture of US socioeconomic and racial/ethnic health inequalities: the Public Health Disparities Geocoding Project. American Journal of Public Health 2005;95(2):312–323. [PubMed: 15671470]

Lamme S, Dykstra PA, van Groenou MIB. Rebuilding the network: new relationships in widowhood. Personal Relationships 1996;3(4):337–349.

Lang FR, Carstensen LL. Close emotional relationships in late life: further support for proactive aging in the social domain. Psychology and Aging 1994;9(2):315–324. [PubMed: 8054179]

Lauderdale DS, Goldberg J. The expanded racial and ethnic codes in the Medicare data files: their completeness of coverage and accuracy. American Journal of Public Health 1996;86(5):712–716. [PubMed: 8629724]

Lillard LA, Waite LJ. Til Death Do Us Part: marital disruption and mortality. American Journal of Sociology 1995;100:1131–1156.

Martikainen P, Valkonen T. Mortality after death of spouse in relation to duration of bereavement in Finland. Journal of Epidemiology and Community Health 1996a;50(3):264–268. [PubMed: 8935456]

Martikainen P, Valkonen T. Mortality after the death of a spouse: rates and causes of death in a large Finnish cohort. American Journal of Public Health 1996b;86(8):1087–1093. [PubMed: 8712266]

Morgan DL, Neal MB, Carder PC. The stability of core and peripheral networks over time. Social Networks 1997;19:9–25.

O'Campo P. Invited commentary: advancing theory and methods for multilevel models of residential neighborhoods and health. American Journal of Epidemiology 2003;157(1):9–13. [PubMed: 12505885]

Parkes CM, Benjamin B, Fitzgerald RG. Broken heart: a statistical study of increased mortality among widowers. British Medical Journal 1969;1(5646):740–743. [PubMed: 5769860]

Pickett KE, Pearl M. Multilevel analyses of neighborhood socioeconomic context and health outcomes: a critical review. Journal of Epidemiology and Community Health 2001;55:111–122. [PubMed: 11154250]

Pope GC, Adamache KW, Walsh EG, Khandker RK. Evaluating alternative risk adjusters for Medicare. Health Care Finance Review 1998;20:109–129.

Rasbash, J.; Steele, F.; Browne, W.; Prosser, B. A user's guide to MLwiN version 2.0. London: Centre for Multilevel Modelling, Institute of Education; 2004.

Raudenbush, S.; Bryk, A. Hierarchical linear models: Applications and data analysis methods. Thousand Oaks: Sage Publications; 2002.

Rook, K.; Sorkin, D.; Zettel, LA. Stress in social relationships: coping and adaptation across the life span. In: Lang, FR.; Fingerman, KL., editors. Growing together: Personal relationships across the life span. New York: Cambridge University Press; 2004. p. 210-239.

Rook, KS.; Schuster, TL. Compensatory processes in the social networks of older adults. In: Pierce, GR.; Sarason, BR.; Sarason, IG., editors. Handbook of social support and the family. New York: Plenum; 1996. p. 219-248.

Sampson RJ. The neighborhood context of well-being. Perspectives in Biology and Medicine 2003;46 (Suppl 3):S53–S64. [PubMed: 14563074]

Schaefer C, Quesenberry CP Jr, Wi S. Mortality following conjugal bereavement and the effects of a shared environment. American Journal of Epidemiology 1995;141(12):1142–1152. [PubMed: 7771452]

Singer JD, Willet JB. It's about time: using discrete-time survival analysis to study duration and the timing of events. Journal of Educational Statistics 1993;18:155–195.

Smith, KP.; Christakis, NA. Widowhood and the risk of sexually transmitted disease in the elderly. Boston: Harvard Medical School; 2007.

Steele F. A discrete-time multilevel mixture model for event history data with long-term survivors, with an application to an analysis of contraceptive sterilization in Bangladesh. Lifetime Data Analysis 2003;9(2):155–174. [PubMed: 12735494]

Subramanian SV. The relevance of multilevel statistical methods for identifying causal neighborhood effects. Social Science & Medicine 2004;58(10):1961–1967. [PubMed: 15020011]

Subramanian SV, Chen JT, Rehkopf DH, Waterman PD, Krieger N. Racial disparities in context: a multilevel analysis of neighborhood variations in poverty and excess mortality among black populations in Massachusetts. American Journal Public Health 2005;95(2):260–265.

Subramanian SV, Chen JT, Rehkopf DH, Waterman PD, Krieger N. Comparing individual- and area-based socioeconomic measures for the surveillance of health disparities: a multilevel analysis of Massachusetts births, 1989–1991. Amer-ican Journal of Epidemiology 2006;164(9):823–834.

Subramanian, SV.; Jones, K.; Duncan, C. Multilevel methods for public health research. In: Kawachi, I.; Berkman, LF., editors. Neighborhoods and health. New York: Oxford University Press; 2003. p. 65-111.

Subramanian SV, Kubzansky L, Berkman L, Fay M, Kawachi I. Neighborhood effects on the self-rated health of elders: uncovering the relative importance of structural and service-related neighborhood environments. Journal of Gerontology B Psychological Science and Social Science 2006;61 (3):S153–S160.

Thomas AJ, Eberly LE, Davey Smith G, Neaton JD. ZIP-code-based versus tract-based income measures as long-term risk-adjusted mortality predictors. American Journal of Epidemiology 2006;164(6): 586–590. [PubMed: 16893922]

Trovato F. Sex, marital status, and suicide in Canada: 1951–1981. Sociological Perspectives 1991;34(4): 427–445. [PubMed: 12343800]

Umberson D. Family status and health behaviors: social control as a dimension of social integration. Journal of Health and Social Behavior 1987;28(3):306–319. [PubMed: 3680922]

Umberson D. Gender, marital status and the social control of health behavior. Social Science & Medicine 1992;34(8):907–917. [PubMed: 1604380]

Umberson D, Wortman CB, Kessler RC. Widowhood and depression: explaining long-term gender differences in vulnerability. Journal of Health and Social Behavior 1992;33(1):10–24. [PubMed: 1619255]

U.S. Census Bureau. Older Americans month celebrated in May. Washington, D.C: U.S. Census Bureau; 2007.

Wen M, Christakis NA. Neighborhood effects on post-hospitalization mortality: a population-based cohort study of the elderly in Chicago. Health Services Research 2005;40(4):1108–1127. [PubMed: 16033495]

Zettel LA, Rook KS. Substitution and compensation in the social networks of older widowed women. Psychology and Aging 2004;19(3):433–443. [PubMed: 15382994]

Zhang JX, Iwashyna TJ, Christakis NA. The performance of different lookback periods and sources of information for Charlson comorbidity adjustment in Medicare claims. Medical Care 1999;37(11): 1128–1139. [PubMed: 10549615]

Table 1

Descriptive statistics (mean and percent) for a sample of elderly married couples in the United States, 1993

Variables	Observations	Mean/percent
Individual/couple	*N* = 200,000	
Mortality		
Husband dies	104,316	52.2
Wife dies	65,279	32.6
Age		
Husband	200,000	76.6 (5.7)
Wife	200,000	74.2 (5.3)
Wife > husband	42,152	22
Co-morbidities score		
0 (Husband)	148,515	74.3
1	19,888	9.9
2	31,597	15.8
0 (Wife)	165,604	82.8
1	14,799	7.4
2	19,597	9.8
Days in hospital (1991–1992)		
Husband	200,000	4.1 (13)
Wife	200,000	3.3 (12)
Race		
White	191,577	95.8
Black	8423	4.2
Poverty		
Non-poor couples	193,430	96.7
Poor couples	6570	3.3

Note: age and days in hospital (1991–1992) were included as continuous variables, and as such their mean (standard deviation) is shown in the above table.

Table 2

Mortality risk (expressed as odds ratio (OR) and 95% confidence interval (CI)) for husbands and wives for widowhood before and after adjusting for neighborhood concentration of widowhood individuals

	Men		Women	
	OR	**95% CI**	**OR**	**95% CI**
Marital status (unadjusted for fraction widowed individuals)				
Married	1		1	
Widowed	1.18	1.16–1.20	1.16	1.14–1.18
Marital status (adjusted for fraction widowed individuals)				
Married	1		1	
Widowed	1.18	1.16–1.20	1.16	1.14–1.18

Note: all models include state, ZIP code, and individual random effects. Models also adjust for time-trends, age of the husbands and wives and the difference, co-morbidities scores for husbands and wives, days in hospital for husbands and wives, race, and couple's poverty status, and neighborhood poverty.

Table 3

Mortality risk (expressed as odds ratio (OR) and 95% confidence interval (CI)) for husbands and wives for neighborhood concentration of widowed individuals

	Men		**Women**	
	OR	**95% CI**	**OR**	**95% CI**
Percent widowed individuals				
Low concentration	1		1	
High concentration	1.00	0.99–1.02	0.98	0.96–0.99
Percent widowers				
Low concentration	1		1	
High concentration	1.00	0.99–1.01	1.00	0.98–1.02
Percent widows				
Low concentration	1		1	
High concentration	1.00	0.99–1.02	0.97	0.96–0.99

Note: all models include state, ZIP code, and individual random effects. Models also adjust for time-trends, age of the husbands and wives and the difference, co-morbidities scores for husbands and wives, days in hospital for husbands and wives, race, and couple's poverty status. Effects associated with percent widowed individuals, percent widowers, and percent widows were estimated separately, and each of these models additionally controlled for percent poor in the ZIP-code.

Table 4

Mortality risk (expressed as odds ratio (OR) and 95% confidence interval (CI)) for men and women based on the interaction between widowhood status at the individual level and neighborhood concentration of widowed individuals at the ZIP-code level

	Men		Women	
	OR	**95% CI**	**OR**	**95% CI**
Marital status and overall concentration of widowed individuals (any gender)				
Marital status				
Married	1		1	
Widowed	1.22	1.18–1.25	1.17	1.14–1.20
Percent widowed individuals				
Low concentration	1		1	
High concentration	1.01	1.00–1.03	0.99	0.97–1.01
Cross-level interaction				
Marital status *x*% widowed individuals	0.96	0.93–0.99	0.99	0.96–1.02
Marital status and concentration of widowed men				
Marital status				
Married	1		1	
Widowed	1.22	1.19–1.25	1.20	1.16–1.23
Percent widowers				
Low concentration	1		1	
High concentration	1.01	1.00–1.03	1.02	1.00–1.04
Cross-level interaction				
Marital status *x*% widowed men	0.95	0.92–0.98	0.96	0.92–0.99
Marital status and concentration of widowed women				
Marital status				
Married	1		1	
Widowed	1.22	1.19–1.25	1.18	1.14–1.21
Percent widows				
Low concentration	1		1	
High concentration	1.01	1.00–1.03	0.98	0.96–1.00
Cross-level interaction				
Marital status *x*% widowed women	0.96	0.93–0.99	0.98	0.95–1.02

Note: the OR and 95% CIs are conditional upon state, ZIP code, and individual random effects. The models also adjust for time-trends, age of the husbands and wives and the difference, co-morbidities scores for husbands and wives, days in hospital for husbands and wives, race, individual poverty status, and ZIP-code-level poverty. Each of the cross-level interaction was separately estimated for men and women. The top panel labeled “Interaction test between marital status and concentration of widowed individuals” presents the odds ratios for the main effects for individual marital status, percent widowed individuals, and the interactions between the two. Similarly, the middle and the bottom panel consider concentration of widowers and widows, respectively, instead of concentration of all widowed individuals.