



**QUEEN'S
UNIVERSITY
BELFAST**

Urban/rural variation in the influence of widowhood on mortality risk: a cohort study of almost 300,000 couples

Wright, D. M., Rosato, M., & O'Reilly, D. (2015). Urban/rural variation in the influence of widowhood on mortality risk: a cohort study of almost 300,000 couples. *Health and Place*, 34, 67-73.
<https://doi.org/10.1016/j.healthplace.2015.04.003>

Published in:
Health and Place

Document Version:
Peer reviewed version

Queen's University Belfast - Research Portal:
[Link to publication record in Queen's University Belfast Research Portal](#)

Publisher rights
© 2015 Elsevier

This is an open access article published under a Creative Commons Attribution-NonCommercial-NoDerivs License (<https://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits distribution and reproduction for non-commercial purposes, provided the author and source are cited.

General rights
Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.

1 **Urban/rural variation in the influence of widowhood on mortality risk: a**
2 **cohort study of almost 300,000 couples**

3 *David M Wright, PhD¹*, Michael Rosato, PhD², Dermot O'Reilly, PhD¹*

4 *¹ Centre for Public Health, Queen's University Belfast, UK*

5 *² Bamford Centre for Mental Health and Wellbeing, University of Ulster, UK*

6 * Corresponding Author: *Centre for Public Health, Institute of Clinical Sciences, Block B,*
7 *Queen's University Belfast, Royal Victoria Hospital, Grosvenor Road, Belfast, BT12 6BA*
8 *UK.*

9 *Tel: +44 2890 632631.*

10 *Email: d.wright@qub.ac.uk*

13 **Urban/rural variation in the influence of widowhood on mortality risk: a**
14 **cohort study of almost 300,000 couples**

15 **ABSTRACT**

16 Death of a spouse is associated with increased mortality risk for the surviving partner (the
17 widowhood effect). We investigated whether the effect magnitude varied between urban, rural
18 and intermediate areas, assembling death records (2001-2009) for a prospective cohort of
19 296,125 married couples in Northern Ireland. The effect was greatest during the first six months
20 of widowhood in all areas and for both sexes. Subsequently, the effect was attenuated among
21 men in rural and intermediate areas but persisted in urban areas (HRs and 95% CIs: rural 1.09
22 [0.99, 1.21]; urban 1.35 [1.26, 1.44]). Among women the effect was attenuated in all areas
23 (rural 1.06 [0.96, 1.17]; urban 1.09 [1.01, 1.17]). The impacts of spousal bereavement varied
24 between urban and more rural areas, possibly due to variation in social support provided by the
25 wider community. We identify men in urban areas as being in greatest need of such support
26 and a possible target for health interventions.

27 **Key words:** widowhood, bereavement, mortality rates, urban/rural

28

29

30 **RESEARCH HIGHLIGHTS**

- 31
- 32 • Mortality risk increases with death of a spouse (the widowhood effect).
 - 33 • The association between area of residence and the widowhood effect was assessed.
 - 34 • A total of 296,125 married couples were included in the analysis.
 - 35 • The widowhood effect was attenuated over time for both sexes in rural areas.
 - 36 • Men in urban areas remained at increased mortality risk but women did not.
- 37

38 INTRODUCTION

39 Widowhood is a common major life transition among older people that has been associated
40 with elevated risk of mortality in the surviving spouse (the widowhood effect) across many
41 populations, providing strong evidence that changes in social ties affect health outcomes (Shor,
42 Roelfs et al. 2012, Manzoli, Villari et al. 2007). Besides gender differences (men usually
43 experience a greater increase in relative risk than women - Moon, Kondo et al. 2011) various
44 socioeconomic and health related factors moderate the widowhood effect (Boyle, Feng et al.
45 2010, Shor, Roelfs et al. 2012, Pandey, Jha 2012) and the largest relative increases in mortality
46 risk are found in groups with low pre-existing risks of mortality (e.g. those with good health
47 and high socioeconomic status - Shah, Carey et al. 2012, Boyle, Feng et al. 2010). Mortality
48 rates associated with a variety of causes are elevated by widowhood indicating that the effect
49 is not limited to a single pathway (Elwert, Christakis 2008) and three main explanatory
50 mechanisms have been proposed: emotional stress and grief, loss of emotional social support
51 and loss of instrumental (task related) social support (Martikainen, Valkonen 1996).

52 The widowhood effect is greatest during the first six months of widowhood (Martikainen,
53 Valkonen 1996, Boyle, Feng et al. 2010, Moon, Kondo et al. 2011, Manor, Eisenbach 2003,
54 Lichtenstein, Gatz et al. 1998, Lusyne, Page et al. 2001), especially deaths related with
55 accidents, violence, alcohol or unexpected respiratory or circulatory diseases (Martikainen,
56 Valkonen 1996, Shah, Carey et al. 2012). A proportion of the excess deaths due to cardiac
57 conditions in the early stages of bereavement may result from inadequate condition
58 management immediately prior to bereavement (Shah, Carey et al. 2013), indicating that acute
59 stress at this stage contributes to the widowhood effect (Vable, Subramanian et al. 2015). As
60 time since bereavement increases the mortality differential between widows and non-widows
61 tends to decrease for women in the first ten years but may increase subsequently, whereas men
62 are likely to show a sustained or increased mortality differential (Shor, Roelfs et al. 2012,
63 Berntsen, Kravdal 2012, Martikainen, Valkonen 1996). In summary, grief and acute stress
64 appear to play a significant role in elevating mortality risk in the early stages of widowhood,
65 replaced over time by more subtle effects due to withdrawal of spousal support in daily living,
66 both emotional and instrumental (Elwert, Christakis 2006, Stroebe, Schut et al. 2007).

67 Estimates of the magnitude of the widowhood effect are heterogeneous among studies but there
68 have been few attempts to identify modifiers other than individual socio-economic or health
69 status (Moon, Kondo et al. 2011), so we investigated the influence of socio-geographic context

70 (urban or rural residence) on the widowhood effect. Urban-rural gradients in risk have been
71 observed for several health outcomes; e.g. all-cause mortality in England (Riva, Curtis et al.
72 2011), mental health status across multiple developed countries, and have been attributed
73 variously to stress, pollution, over-concentrated housing or social isolation in urban areas
74 (O'Reilly, O' Reilly et al. 2007, Peen, Schoevers et al. 2010). However, in some contexts health
75 gradients show the opposite pattern with higher incidence of suicide, more severe injuries from
76 road accidents and delayed cancer diagnosis in rural parts of some countries (Campbell, Elliott
77 et al. 2001, Levin, Leyland 2005, Weiss, Kaplan et al. 2014).

78 Of the factors thought to contribute to urban-rural health gradients, social environment may
79 modify the widowhood effect at different stages of bereavement by two different mechanisms.
80 Acute stress during early bereavement may be buffered by intentionally supportive interactions
81 within an individual's social network (or at least the perception that emotional, informational
82 or instrumental support is available - Thoits 2011, Holt-Lunstad, Smith et al. 2010). As time
83 since bereavement increases the 'main-effects' of social relationships may come to the fore; a
84 set of emotional, behavioural or cognitive processes stemming from social relationships that
85 are not intentionally supportive but often have beneficial influences on health (e.g. societal
86 pressure to fulfil a family role may cause people to adopt a healthy lifestyle to fulfil that role -
87 Thoits 2011). There is some evidence that social support during widowhood influences health
88 outcomes including mortality risk. A study collating vital event records for over 400,000
89 elderly couples in the US showed that the race of the partners influences the widowhood effect.
90 Whites in endogamous marriages suffered a large increase in mortality risk but the effect was
91 not evident among blacks, a distinction that may be related to higher levels of familial support
92 for the elderly in black families (Elwert, Christakis 2006).

93 We investigated the association between the widowhood effect and urban or rural residence,
94 using a large cohort of married couples assembled from the Northern Ireland Mortality Study.
95 In Northern Ireland older people living in rural areas receive more family support, being more
96 likely to live with their children and hence less likely to be admitted to care homes (McCann,
97 Grundy et al. 2014). Adjusting for these differences in family living arrangements, there is an
98 additional reduction in risk of admission to care homes among rural dwellers in comparison
99 with urban dwellers, indicating that greater integration within the wider community may reduce
100 demand for formal care services or replace them when supply is limited (McCann, Grundy et
101 al. 2014). Therefore we predicted that the mortality differential between widows and non-
102 widows would be less pronounced in rural compared with urban areas, especially once the

103 initial period of shock had passed and the availability of longer term instrumental and
104 emotional support had become of greater importance. We investigated these relationships
105 separately for men and women to account for differences in the size of the widowhood effect
106 between sexes (Moon, Kondo et al. 2011).

107 **METHODS**

108 *Data sources*

109 The Northern Ireland Mortality Study 2001 (NIMS 2001) is a prospective record-linkage study,
110 derived from the 2001 Census returns for the whole enumerated population (c1.6m), to which
111 subsequent registered deaths to the end of 2009 have been linked. Details of NIMS 2001 and
112 linkage processes are described elsewhere (O'Reilly, Rosato et al. 2012, O'Reilly, Rosato et al.
113 2008). These data were anonymised, held in a safe setting by the Northern Ireland Statistics
114 and Research Agency (NISRA) and made available to the research team for this study. The use
115 of the NIMS 2001 for research was approved by the Office for Research Ethics Committees
116 Northern Ireland (ORECNI).

117 *Definition of cohort*

118 All personal characteristics were drawn from the Census returns which were also used to
119 identify married couples whose members were aged from 26 to 103 at the time of the 2001
120 Census. Couples living in institutional settings (e.g. nursing homes or sheltered
121 accommodation) were excluded. It was not possible to exclude couples who were separated
122 before the death of the first partner. A small number of couples (66) were excluded in which
123 both members died of a common cause within the same calendar month, leaving a total of
124 296,125 couples. This group experienced 37,821 deaths during the follow-up period (Table 1).

125 *Characteristics of the cohort*

126 In addition to age, sex, religious affiliation and country of birth the following characteristics
127 that have previously been associated with increased mortality risk were extracted from the
128 census records. Five indicators of socio-economic status were included: household car access;
129 educational attainment; social class, derived using the National Statistics Socio-economic
130 Classification (NS-SEC)(Rose, Pevalin 2002); economic activity; and housing tenure
131 (Connolly, O'Reilly et al. 2010)(Table 1). The Census included two indicators of self-reported
132 morbidity – the presence of a long-term illness limiting usual activities; and another on general
133 health in the previous year. The amount of time spent caring for other family members or those
134 with health problems was also recorded, along with the presence of any dependent children

135 (Ramsay, Grundy et al. 2013, O'Reilly, Connolly et al. 2008). We also sought to adjust for
136 variation in family living arrangements between urban and rural areas (McCann, Grundy et al.
137 2014), recording the presence of other adults in the household who may provide support for
138 the bereaved.

139 ***Definition of urban and rural areas***

140 Although there is no universally agreed definition of what constitutes an 'urban' or 'rural' area,
141 the official classification in Northern Ireland (NISRA 2005) uses an approach based on
142 population size, density and access to services to group small population tracts of about 300
143 people into eight settlement bands ranging from the largest, the Metropolitan Area of Belfast
144 (comprising c.580,000 people); to a band representing settlements of less than 1000 people and
145 open countryside. Cohort members were allocated to settlement bands based on place of
146 residence on Census day. Our cohort was unequally distributed among the eight settlement
147 bands (95,714 couples in Belfast compared with 12,307 in villages; Supplementary Materials,
148 Table S1), reducing the power of our analyses to detect temporal trends for the smaller bands
149 and so we re-categorised the bands into three similarly sized groups; urban – comprising the
150 largest two cities; intermediate – combining large, medium, and small towns and intermediate
151 areas, and rural as above.

152 ***Analytical methods***

153 The primary outcome measure was all-cause mortality during follow-up on a chronological age
154 timescale. We estimated mortality rates using a Cox proportional hazards model to obtain
155 hazard ratios (HRs) and 95% confidence intervals (CIs), adjusting for age and all measured
156 characteristics of the household and of the individual (but not of the spouse). Baseline hazards
157 of mortality for men and women are known to be quite different (especially with respect to
158 age) and so separate models were fitted for each sex, rather than a single more complex model
159 with a large number of interaction terms. As a result, between sex comparisons of effect sizes
160 are indirect. A piecewise structure (five time periods) allowed for changes in baseline mortality
161 rates during follow-up as the cohort aged. Recognising that participant characteristics may
162 change during follow-up (e.g. health status improving or declining), we used statistical tests to
163 determine which covariates should be treated as time-varying and which time-invariant. We
164 tested whether there was a significant interaction between each covariate and time period
165 (Likelihood ratio test comparing models with and without a time interaction) using the whole
166 cohort. Covariates selected for subsequent models whose effects were allowed to vary over

167 time were: economic activity, car access (males only); household size, housing tenure (females
168 only); caregiving status, long-term limiting illness, general health (both sexes), with the
169 remaining covariates treated as time-invariant.

170 Time since widowhood was included as a time-varying covariate in all models and we
171 conducted two separate analyses, first dividing widowhood into early (< 6 months) and later (6
172 months to 8.7 years) stages. The six month division was selected based on preliminary analysis
173 of the widowhood curve and the approach of previous studies which have identified the first
174 six months as the period of highest risk, associated with shock and acute grief. The effects of
175 changing health behaviours and instrumental support deficits are of greater importance at later
176 stages (Martikainen, Valkonen 1996, Stroebe, Schut et al. 2007, Lusyne, Page et al. 2001,
177 Manor, Eisenbach 2003). To determine whether the effect of each stage of widowhood varied
178 with rurality, we compared models with and without interactions between widowhood duration
179 and rurality (using likelihood ratio tests). The effect of living arrangements (whether couples
180 were living with other adults at baseline) was tested in a similar manner (i.e. testing for
181 interaction between living arrangements and widowhood duration).

182 In the second analysis widowhood duration was further divided at 1, 3, 6 and 12 months and
183 then annually post-bereavement to determine the trajectory of the widowhood effect. We also
184 conducted a sensitivity analysis to determine whether three-way categorisation of settlement
185 bands masked variability among bands, performing separate analyses for each of the eight
186 bands. All analyses were conducted in Stata version 12 (StataCorp, College Station, Texas).

187 **RESULTS**

188 Summary statistics describing the population at baseline (Table 1) showed that those widowed
189 were older on average than non-widows and hence more likely to have poor health, lower levels
190 of education, be economically inactive and live in smaller households with fewer dependent
191 children. There was no difference between groups or consistent urban/rural gradient in the
192 proportion of couples living with other adults (Table S1).

193 The relative effects of each stage of widowhood varied significantly among areas (likelihood
194 ratio tests for interaction between duration and rurality: men, $P = 0.008$; women $P = 0.061$).
195 Men in urban, intermediate and rural areas had significantly increased hazard of mortality in
196 the first six months of widowhood compared with those that were not widowed (HRs: 1.25 in
197 urban areas, 1.50 in rural and intermediate areas, Table 2). Excess mortality increased again at

198 the later stages (>6 months) of widowhood for men in urban areas but not in intermediate or
199 rural areas where the mortality differentials decreased.

200 Among women, the pattern of responses to widowhood across areas in the first six months was
201 similar to that observed among men (i.e. elevated mortality risk in each area but a much smaller
202 increase in urban areas). In all areas the mortality differential between widows and non-widows
203 decreased in the later stages of widowhood. The largest sustained elevation in risk was in
204 intermediate areas followed by urban areas (HRs of 1.22 and 1.09 respectively) with no
205 significant difference remaining in rural areas (Table 2).

206 These effects were reflected in the trajectories of the widowhood effects for each group over
207 time (Figure 1). In rural areas the large initial spike in relative mortality (HRs in the first month
208 1.71 and 1.67 for men and women respectively) dissipated by the end of the first year of
209 widowhood and a similar trajectory was observed in intermediate areas. Women in urban areas
210 suffered a modest initial increase in mortality (HR of 1.11 during the first month) but there was
211 no sustained elevation in mortality risk after the first year of widowhood (Figure 1). In contrast,
212 men in urban areas showed a greater relative initial increase in mortality risk than women (HR
213 = 1.38 in first month) but the effect persisted and appeared to increase slightly in magnitude
214 during subsequent years. Sensitivity analysis revealed that trajectories of mortality risk were
215 similar across settlement bands within each of the (three-way) urban/rural area classifications
216 although there was considerable uncertainty around risk estimates in bands comprising less
217 than 20,000 couples (not shown – available on request).

218 Mortality risks for couples living with other adults were elevated compared with couples not
219 living with others at baseline (fully adjusted models, all areas combined, HRs and 95% CIs:
220 men, 1.11 [1.08, 1.14]; women, 1.10 [1.05, 1.14]). However, living with other adults was not
221 associated with variation in responses to widowhood for either sex in any area (Likelihood ratio
222 tests for interaction between living arrangements and widowhood duration split at six months,
223 all tests $P > 0.05$, Table S2).

224 **DISCUSSION**

225 Our estimates of the increase in mortality risk following widowhood are consistent with those
226 found across multiple studies in developed countries (Shor, Roelfs et al. 2012). In intermediate
227 areas, the pattern that we observed of high excess mortality within the early stages of
228 widowhood followed by decreased but still elevated risk in the later stages is very similar to

229 that reported in both Scotland and Finland (Boyle, Feng et al. 2010, Martikainen, Valkonen
230 1996). However, neither the rapid attenuation of the widowhood effect among the rural
231 bereaved, matching that of non-widows within a year, nor the increasing magnitude of the
232 effect over time among urban dwelling men, have been observed previously. Urban/rural
233 differentials in the widowhood effect remained after adjusting for a wide range of individual
234 predictors that have been associated with variation in mortality risk (e.g. age, social class,
235 health status) but have been frequently overlooked in studies of widowhood (Moon, Kondo et
236 al. 2011). These findings highlight the importance of both individual-level predictors and social
237 context as predictors of health outcomes in Ireland (Tay, Kelleher et al. 2004).

238 In the later stages of widowhood, we found a decreasing trend in magnitude of the widowhood
239 effect from urban to rural areas among men and from intermediate to rural areas among women.
240 These results are consistent with our prediction that the widowhood effect would be less
241 pronounced over the long-term in rural areas in comparison with more densely populated areas
242 and provide support for our hypothesis that the effect is attenuated by greater social integration.
243 However, the urban-rural gradient may also be a proxy for other factors which influence the
244 widowhood effect. For example, residential proximity to green spaces has been associated with
245 less severe declines in general and mental health following stressful life events (van den Berg,
246 Maas et al. 2010) which might eventually manifest as area-specific variation in mortality risk.
247 Furthermore, the effects of proximity to green space on some health outcomes are sex-specific;
248 a UK based study of urban residents found that mortality risk from cardiovascular and
249 respiratory disease decreased with increased access to green space among men but no such
250 association was found among women (Richardson, Mitchell 2010). One explanation for this
251 difference is that proximity to green space encourages regular physical activity among men,
252 but that perceived safety concerns and other social barriers may prevent women from deriving
253 the same health benefits. Similarly, sex-specific differences in the long-term trajectory of the
254 widowhood effect along the urban-rural gradient may be due to differential influence of the
255 residential and occupational environment on levels of physical activity of men and women.
256 Specifically, a recent systematic review (Stahl, Schulz 2014) found limited evidence for an
257 association between bereavement and reduced levels of physical activity (both sports and other
258 leisure activities) among men but not among women. A reduction in physical activity and hence
259 cardiovascular health may partially explain the increased mortality risk for men in urban areas
260 during later stages of widowhood. A similar drop in activity may not have occurred among
261 rural widowers because in these areas manual occupations (particularly farming) are more

262 common and so levels of occupational physical activity remain high. In rural parts of Northern
263 Ireland continued engagement in the workforce past normal retirement age is relatively
264 common and may maintain greater social integration among older men than would occur in
265 urban areas (Heenan 2010), potentially contributing to the observed urban-rural differences in
266 the widowhood effect.

267 Urban-rural variation in access to medical care might also have influenced mortality risk among
268 the bereaved; greater distances to primary care services may have discouraged health check
269 attendance of rural residents around the time of bereavement, increasing mortality risk from
270 pre-existing conditions (Shah, Carey et al. 2013). This may explain why the widowhood effect
271 was greater in rural and intermediate than in urban areas during the first six months but it is
272 more difficult to envisage how it might explain the sustained increases in risk among urban but
273 not among rural men. In contrast with the urban-rural differences, presence of other adults was
274 not associated with a decrease in the widowhood effect. This is surprising as during the early
275 stages of bereavement family members are likely to have the most frequent interactions with
276 the bereaved. One hypothesis is that members of the household and the wider community have
277 differing influences on health outcomes of widowed people and that sources of effective social
278 support are situation specific (Thoits 2011). A synthesis of 50 studies of the association
279 between social support and mortality (not at times of bereavement), showed that perceived
280 social support from family members is more beneficial for reducing mortality risk than support
281 from friends (Shor, Roelfs et al. 2013). However, widowhood presents a particular set of
282 emotional challenges and there is evidence that bereaved people find contact with friends
283 promotes emotional well-being and decreases loneliness to a greater extent than contact with
284 family, perhaps because friends freely choose to interact with the bereaved and are less likely
285 to initiate contact out of obligation (Utz, Swenson et al. 2013, de Vries, Utz et al. 2013). This
286 potentially explains why urban/rural variation, which may indicate interaction with the wider
287 community, was associated with the widowhood effect whilst household composition which is
288 likely to indicate contact with family members was not. A similar distinction between
289 household and broader community effects relates to care provision for older people in Northern
290 Ireland; living with children and rural residence were independently associated with lower risk
291 of care home admission among older people (McCann, Grundy et al. 2014). Furthermore, an
292 Australian study found that a high degree of social integration with friends was associated with
293 increased survival among older people but the same relationship was not evident for contact
294 with relatives (Giles, Glonek et al. 2005). Finally, the role of family members in supporting the

295 bereaved may have been obscured in our study because living with others may not accurately
296 represent the support available. A recent meta-analysis revealed that structural measures of
297 social relationships including indicators of residential status are more weakly associated with
298 mortality than more complex measures which also incorporate levels of perceived or received
299 support (Holt-Lunstad, Smith et al. 2010).

300 A limitation to our study was that covariates were only measured at baseline (the 2001 Census)
301 so discrepancies between observed and true values are likely to have increased over time,
302 potentially obscuring associations with the widowhood effect. Self-reported health status is
303 most likely to have changed during follow up, especially amongst older widowed groups, and
304 we attempted to adjust for this by using time-varying effects in our survival models where
305 necessary. This consideration also applies to living arrangements; people may have chosen to
306 move in with others post-bereavement and propensity to move may have varied along the
307 urban/rural gradient. Area of residence may also have changed and in Northern Ireland there
308 has been a net migration from deprived to more affluent areas, typically from cities to the
309 surrounding hinterland, with migrants more likely to be affluent than non-migrants (O'Reilly,
310 Stevenson 2003), and to possess better long term health prospects. The widowhood effect is
311 more pronounced in groups with these characteristics (Shah, Carey et al. 2012) and so selective
312 migration during follow-up could have biased downwards our estimates of the widowhood
313 effect in urban areas. However, migration over large distances is rare (2.9% of the population
314 move between postcode sectors annually - O'Reilly, Stevenson 2003) and is less common at
315 the ages where most widowhood occurs. As our urban/rural classification did not require
316 adjustment as a time-varying effect we expect any associated bias to be minor.

317 The Northern Ireland Mortality Study incorporates baseline measurements of marital status and
318 subsequent deaths but not other vital events including divorce and remarriage. Some of the
319 couples in our sample may have been no longer married when the first death occurred, leaving
320 the surviving partner unlikely to suffer the widowhood effect (Elwert, Christakis 2008). The
321 inclusion of this group might bias our estimates of widowhood effect downwards by increasing
322 average mortality rates in the non-widowed group (divorce is also associated with elevated
323 mortality rates - Berntsen, Kravdal 2012, Waite 1995). Any bias is likely to be small because
324 the magnitude of the 'divorce effect' is similar to the widowhood effect (Shor, Roelfs et al.
325 2012, Rendall, Weden et al. 2011). Also, divorce rates amongst the over 60s (the majority of
326 our sample) are likely to be relatively low, as indicated by age-specific rates in comparable
327 populations in England and Wales (Office of National Statistics 2011).

328 The modelled variables spanned a wide range of factors likely to influence mortality risk,
329 including measures of self-reported health not usually available for a cohort of this size but it
330 is possible that the observed patterns was driven by variation in an unobserved covariate (e.g.
331 smoking status), a limitation common to many other observational studies of this type.
332 Similarly, urban/rural residence may not accurately reflect received support at the community
333 level (impracticable to measure at large scales, requiring surveys of visits received etc.) and so
334 other interpretations of our results are possible. For example, the observed urban/rural
335 differences may be due to an alternative mechanism, perhaps differences in attitudes to
336 mortality across the urban/rural divide. In Northern Ireland, death is a much larger part of life
337 in rural areas than in cities; news of a death travels fast, attendance at wakes and funerals of
338 even distant acquaintances is expected and these events are important forums for community
339 interaction, aside from providing comfort for the bereaved. As a result, rural funerals tend to
340 be larger than those in urban areas and the considerable stress of mourning in a more prominent
341 setting may contribute towards the larger initial spike in mortality risk that we observed in rural
342 and intermediate compared with in urban areas.

343 **CONCLUSION**

344 In conclusion, we found pronounced urban/rural differences in the effects of widowhood on
345 mortality risk. In urban, rural and intermediate areas we found that in the early stages of
346 widowhood (< 6 months) all groups had elevated risks of mortality but the effect was much
347 less pronounced among urban dwellers. In later stages the effect dissipated for rural dwellers
348 and to some extent for intermediate dwellers and urban dwelling women but not for urban
349 dwelling men who remained at a higher risk of mortality than their married counterparts for
350 many years. These effects may be attributable to the positive influence of greater social
351 integration of widowed people into the wider community in rural compared with more densely
352 populated areas. Urban-dwelling men at later stages of widowhood appear to have the greatest
353 need for community support and efforts to increase integration into the wider community might
354 bring considerable benefits for this group.

355

356 **ACKNOWLEDGMENTS**

357 This study was funded as part of the UK Centre of Excellence for Public Health, Northern
358 Ireland initiative. The funders had no direct role in the conduct of the study; the collection,
359 management, analyses, or interpretation of the data; or the preparation or approval of the
360 manuscript.

361 The help provided by the staff of the Northern Ireland Mortality Study 2001 (NIMS 2001) and
362 the NILS Research Support Unit is acknowledged. The NIMS 2001 is funded by the Health
363 and Social Care Research and Development Division of the Public Health Agency (HSC R&D
364 Division) and NISRA. The NILS-RSU is funded by the ESRC and the Northern Ireland
365 Government. The authors alone are responsible for the interpretation of the data and any views
366 or opinions presented are solely those of the author and do not necessarily represent those of
367 NISRA/NILS.

368

370 **REFERENCES**

- 371 BERNTSEN, K.N. and KRAVDAL, Ø, 2012. The relationship between mortality and time
372 since divorce, widowhood or remarriage in Norway. *Social science & medicine*, **75**(12), pp.
373 2267-2274.
- 374 BOYLE, P.J., FENG, Z. and RAAB, G.M., 2010. Does Widowhood Increase Mortality Risk?:
375 Testing for Selection Effects by Comparing Causes of Spousal Death. *Epidemiology*
376 (*Cambridge, Mass.*), **22**, pp. 1-5.
- 377 CAMPBELL, N.C., ELLIOTT, A.M., SHARP, L., RITCHIE, L.D., CASSIDY, J. and
378 LITTLE, J., 2001. Rural and urban differences in stage at diagnosis of colorectal and lung
379 cancers. *British journal of cancer*, **84**(7), pp. 910-914.
- 380 CONNOLLY, S., O'REILLY, D. and ROSATO, M., 2010. House value as an indicator of
381 cumulative wealth is strongly related to morbidity and mortality risk in older people: a census-
382 based cross-sectional and longitudinal study. *International journal of epidemiology*, **39**(2), pp.
383 383-391.
- 384 DE VRIES, B., UTZ, R., CASERTA, M. and LUND, D., 2013. Friend and Family Contact and
385 Support in Early Widowhood. *The Journals of Gerontology Series B: Psychological Sciences*
386 *and Social Sciences*, **69B**(1), pp. 75 - 84.
- 387 ELWERT, F. and CHRISTAKIS, N.A., 2008. The Effect of Widowhood on Mortality by the
388 Causes of Death of Both Spouses. *American Journal of Public Health*, **98**(11), pp. 2092-2098.
- 389 ELWERT, F. and CHRISTAKIS, N.A., 2006. Widowhood and Race. *American Sociological*
390 *Review*, **71**(1), pp. 16-41.
- 391 ELWERT, F. and CHRISTAKIS, N., 2008. Wives and ex-wives: A new test for homogamy
392 bias in the widowhood effect. *Demography*, **45**(4), pp. 851-873.
- 393 GILES, L.C., GLONEK, G.F.V., LUSZCZ, M.A. and ANDREWS, G.R., 2005. Effect of social
394 networks on 10 year survival in very old Australians: the Australian longitudinal study of aging.
395 *Journal of Epidemiology and Community Health*, **59**(7), pp. 574-579.
- 396 HEENAN, D., 2010. Social capital and older people in farming communities. *Journal of Aging*
397 *Studies*, **24**(1), pp. 40-46.
- 398 HOLT-LUNSTAD, J., SMITH, T.B. and LAYTON, J.B., 2010. Social Relationships and
399 Mortality Risk: A Meta-analytic Review. *PLoS Med*, **7**(7), pp. e1000316.
- 400 LEVIN, K.A. and LEYLAND, A.H., 2005. Urban/rural inequalities in suicide in Scotland,
401 1981–1999. *Social science & medicine*, **60**(12), pp. 2877-2890.

- 402 LICHTENSTEIN, P., GATZ, M. and BERG, S., 1998. A twin study of mortality after spousal
403 bereavement. *Psychological medicine*, **28**(03), pp. 635-643.
- 404 LUSYNE, P., PAGE, H. and LIEVENS, J., 2001. Mortality following conjugal bereavement,
405 Belgium 1991-96: The unexpected effect of education. *Population Studies*, **55**(3), pp. 281-289.
- 406 MANOR, O. and EISENBACH, Z., 2003. Mortality after spousal loss: are there socio-
407 demographic differences? *Social science & medicine*, **56**(2), pp. 405-413.
- 408 MANZOLI, L., VILLARI, P., M PIRONE, G. and BOCCIA, A., 2007. Marital status and
409 mortality in the elderly: A systematic review and meta-analysis. *Social science & medicine*,
410 **64**(1), pp. 77-94.
- 411 MARTIKAINEN, P. and VALKONEN, T., 1996. Mortality after death of spouse in relation to
412 duration of bereavement in Finland. *Journal of epidemiology and community health*, **50**(3), pp.
413 264-268.
- 414 MARTIKAINEN, P. and VALKONEN, T., 1996. Mortality after the death of a spouse: rates
415 and causes of death in a large Finnish cohort. *American Journal of Public Health*, **86**(8), pp.
416 1087-1093.
- 417 MCCANN, M., GRUNDY, E. and O'REILLY, D., 2014. Urban and rural differences in risk of
418 admission to a care home: A census-based follow-up study. *Health and Place*, **30**, pp. 171-176.
- 419 MOON, J.R., KONDO, N., GLYMOUR, M.M. and SUBRAMANIAN, S.V., 2011.
420 Widowhood and mortality: a meta-analysis. *PloS one*, **6**(8), pp. e23465.
- 421 NISRA, 2005. *Report of the inter-departmental urban-rural definition group: statistical*
422 *classification and delineation of settlements*. Belfast: Northern Ireland Statistics and Research
423 Agency.
- 424 O'REILLY, D., ROSATO, M., CATNEY, G., JOHNSTON, F. and BROLLY, M., 2012.
425 Cohort description: The Northern Ireland Longitudinal Study (NILS). *International journal of*
426 *epidemiology*, **41**(3), pp. 634-641.
- 427 O'REILLY, D. and STEVENSON, M., 2003. Selective migration from deprived areas in
428 Northern Ireland and the spatial distribution of inequalities: implications for monitoring health
429 and inequalities in health. *Social science & medicine*, **57**(8), pp. 1455-1462.
- 430 OFFICE OF NATIONAL STATISTICS, 2011-last update, Divorces in England and Wales -
431 2011 [Homepage of Office of National Statistics], [Online]. Available:
432 <http://www.ons.gov.uk/ons/rel/vsob1/divorces-in-england-and-wales/2011/index.html>.
- 433 O'REILLY, G., O' REILLY, D., ROSATO, M. and CONNOLLY, S., 2007. Urban and rural
434 variations in morbidity and mortality in Northern Ireland. *BMC Public Health*, **7**(1), pp. 123.
- 435 O'REILLY, D., CONNOLLY, S., ROSATO, M. and PATTERSON, C., 2008. Is caring
436 associated with an increased risk of mortality? A longitudinal study. *Social science & medicine*,
437 **67**(8), pp. 1282-1290.

- 438 O'REILLY, D., ROSATO, M. and CONNOLLY, S., 2008. Unlinked vital events in census-
439 based longitudinal studies can bias subsequent analysis. *Journal of clinical epidemiology*,
440 **61**(4), pp. 380-385.
- 441 PANDEY, M.K. and JHA, A.K., 2012. Widowhood and health of elderly in India: examining
442 the role of economic factors using structural equation modeling. *International Review of*
443 *Applied Economics*, **26**(1), pp. 111-124.
- 444 PEEN, J., SCHOEVEERS, R.A., BEEKMAN, A.T. and DEKKER, J., 2010. The current status
445 of urban-rural differences in psychiatric disorders. *Acta Psychiatrica Scandinavica*, **121**(2), pp.
446 84-93.
- 447 RAMSAY, S., GRUNDY, E. and O'REILLY, D., 2013. The relationship between informal
448 caregiving and mortality: an analysis using the ONS Longitudinal Study of England and Wales.
449 *Journal of epidemiology and community health*, **67**, pp. 655-660.
- 450 RENDALL, M.S., WEDEN, M.M., FAVREAU, M.M. and WALDRON, H., 2011. The
451 Protective Effect of Marriage for Survival: A Review and Update. *Demography*, **48**(2), pp.
452 481-506.
- 453 RICHARDSON, E.A. and MITCHELL, R., 2010. Gender differences in relationships between
454 urban green space and health in the United Kingdom. *Social science & medicine*, **71**(3), pp.
455 568-575.
- 456 RIVA, M., CURTIS, S. and NORMAN, P., 2011. Residential mobility within England and
457 urban-rural inequalities in mortality. *Social science & medicine*, **73**(12), pp. 1698-1706.
- 458 ROSE, D. and PEVALIN, D., 2002. *A Researcher's guide to the national statistics socio-*
459 *economic classification*. London: Sage.
- 460 SHAH, S.M., CAREY, I.M., HARRIS, T., DEWILDE, S., VICTOR, C.R. and COOK, D.G.,
461 2012. Do Good Health and Material Circumstances Protect Older People From the Increased
462 Risk of Death After Bereavement? *American Journal of Epidemiology*, **176**, pp. 689-698.
- 463 SHAH, S.M., CAREY, I.M., HARRIS, T., DEWILDE, S., VICTOR, C.R. and COOK, D.G.,
464 2013. Impact of Partner Bereavement on Quality of Cardiovascular Disease Management.
465 *Circulation*, **128**(25), pp. 2745-2753.
- 466 SHOR, E., ROELFS, D.J., BUGYI, P. and SCHWARTZ, J.E., 2012. Meta-analysis of marital
467 dissolution and mortality: Reevaluating the intersection of gender and age. *Social Science and*
468 *Medicine*, **75**(1), pp. 46-59.
- 469 SHOR, E., ROELFS, D.J. and YOGEV, T., 2013. The strength of family ties: A meta-analysis
470 and meta-regression of self-reported social support and mortality. *Social Networks*, **35**(4), pp.
471 626-638.
- 472 SHOR, E., ROELFS, D., CURRELI, M., CLEMOW, L., BURG, M. and SCHWARTZ, J.,
473 2012. Widowhood and Mortality: A Meta-Analysis and Meta-Regression. *Demography*, **49**(2),
474 pp. 575-606.

- 475 STAHL, S. and SCHULZ, R., 2014. Changes in Routine Health Behaviors Following Late-life
476 Bereavement: A Systematic Review. *Journal of Behavioral Medicine*, **37**(4), pp. 736-755.
- 477 STROEBE, M., SCHUT, H. and STROEBE, W., 2007. Health outcomes of bereavement. *The*
478 *Lancet*, **370**(9603), pp. 1960-1973.
- 479 TAY, J.B., KELLEHER, C.C., HOPE, A., BARRY, M., GABHAINN, S.N. and SIXSMITH,
480 J., 2004. Influence of sociodemographic and neighbourhood factors on self rated health and
481 quality of life in rural communities: findings from the Agriproject in the Republic of Ireland.
482 *Journal of Epidemiology and Community Health*, **58**(11), pp. 904-911.
- 483 THOITS, P.A., 2011. Mechanisms Linking Social Ties and Support to Physical and Mental
484 Health. *Journal of health and social behavior*, **52**(2), pp. 145-161.
- 485 UTZ, R.L., SWENSON, K.L., CASERTA, M., LUND, D. and DEVRIES, B., 2013. Feeling
486 Lonely Versus Being Alone: Loneliness and Social Support Among Recently Bereaved
487 Persons. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*,
488 **69B**(1), pp. 85- 94.
- 489 VABLE, A.M., SUBRAMANIAN, S.V., RIST, P.M. and GLYMOUR, M.M., 2015. Does the
490 “widowhood effect” precede spousal bereavement? Results from a Nationally Representative
491 Sample of Older Adults. *The American Journal of Geriatric Psychiatry*, **23**(3), pp. 283-292.
- 492 VAN DEN BERG, A.E., MAAS, J., VERHEIJ, R.A. and GROENEWEGEN, P.P., 2010.
493 Green space as a buffer between stressful life events and health. *Social science & medicine*,
494 **70**(8), pp. 1203-1210.
- 495 WAITE, L.J., 1995. Does Marriage Matter? *Demography*, **32**(4), pp. 483-507.
- 496 WEISS, H.B., KAPLAN, S. and PRATO, C.G., 2014. Analysis of factors associated with
497 injury severity in crashes involving young New Zealand drivers. *Accident Analysis &*
498 *Prevention*, **65**(0), pp. 142-155.
- 499

Table 1. Baseline characteristics of married couples in Northern Ireland, 2001, by widowhood (2001-2009) and sex.

	Males	Widowers	Females	Widows
Cohort (no.)	283,685	12,440	270,744	25,381
Deaths	25,447	2,658	12,506	2,962
Person years at risk	2,428,777	44,961.25	2,428,777	101,339.5
Annual mortality risk (%)	1.05	5.91	0.51	2.92
Age – mean (SD)	49.9 (13.7)	66.4 (12.1)	46.9 (12.8)	64.7 (11.3)
Economic activity ^a				
Employed	49.28	17.97	50.63	17.22
Self employed	18.13	8.20	4.63	1.98
Unemployed	2.90	1.75	1.48	0.54
Inactive	24.59	44.05	41.08	60.46
Aged 75+	5.10	28.03	2.19	19.80
Social class (NS-SEC) ^a				
Professional	32.06	19.08	28.81	15.63
Intermediate	6.09	4.24	17.13	11.15
Small employers/self employed	18.44	11.47	4.93	3.59
Lower supervisory	7.20	6.22	4.53	3.72
(Semi) routine	28.50	28.20	37.60	38.20
Never worked/Long term unemployed/full-time student	2.62	2.74	4.82	7.92
Education ^a				
No qualifications	47.02	53.49	40.14	58.61
Foundation level	14.11	4.16	17.86	6.03
GCSEs	10.83	5.05	17.45	8.15
2+ A-Levels	4.94	1.58	6.71	1.94
First degree	11.77	5.21	11.36	4.22
Higher degree	6.24	2.48	4.29	1.25
Car access				
None	6.76	18.22	6.05	19.93
One	43.59	56.06	43.16	54.29
Two+	49.65	25.72	50.79	25.78
Housing tenure				
Owner occupied	87.39	76.67	87.76	78.16
Privately rented	4.02	4.49	3.98	4.73
Social rented	8.59	18.83	8.26	17.11
Long term limiting illness				
Yes	23.73	44.34	21.56	43.34
No	76.27	55.66	78.44	56.66
General health				
Good	64.78	42.67	63.11	39.44
Fair	22.72	36.46	23.99	37.69
Not good	12.50	20.87	12.9	22.88
Unpaid carer				
None	84.93	73.1	79.33	72.41
1-19 hours	9.60	7.72	12.63	7.96
20-49 hours	1.93	4.08	3.12	4.05
50+ hours	3.54	15.10	4.93	15.57
Dependent children				
None	48.77	87.45	46.82	88.53
One	16.59	6.42	17.11	6.01

	Two	20.16	3.73	20.99	3.24
	Three+	14.48	2.40	15.08	2.23
Other adults in household					
	No	71.73	70.92	71.81	70.52
	Yes	28.27	29.08	28.19	29.48
Country of birth					
	Northern Ireland	89.96	89.72	89.55	90.01
	England	4.45	3.96	3.87	2.90
	Scotland	1.24	1.58	1.13	1.11
	Wales	0.26	0.27	0.17	0.20
	Republic of Ireland	2.38	3.55	3.45	4.63
	Ireland (place not specified)	0.16	0.13	0.14	0.12
	Other	1.55	0.79	1.69	1.02
Religion (community background)					
	Roman Catholic	36.87	32.43	38.61	32.08
	Presbyterian	26.66	28.84	25.90	30.07
	Church of Ireland	18.46	21.91	18.44	21.66
	Methodist	4.53	5.14	4.57	5.44
	Other Christian	10.88	9.98	10.41	9.40
	Other/none	2.61	1.70	2.07	1.35
Rurality					
	Urban	36.4	43.4	36.2	41.7
	Intermediate	33.6	32.2	33.8	31.7
	Rural	30.0	24.4	30.0	26.6

501 Abbreviation: SD, standard deviation.

502 Percentage of cases in each cohort at baseline given for categorical variables.

503 ^a Economic activity, social class and education variables have the same percentage of cases
504 with participants aged 75+. Percentages listed for economic activity only.

505

Table 2. Effect of widowhood on hazard of mortality by rurality and temporal stage of widowhood, Northern Ireland, 2001-2009.

<i>Rurality</i>	Men		Women	
	< 6 months	≥ 6 months	< 6 months	≥ 6 months
Urban	1.25 (1.07, 1.47)	1.35 (1.26, 1.44)	1.24 (1.06, 1.46)	1.09 (1.01, 1.17)
Intermediate	1.50 (1.25, 1.80)	1.22 (1.13, 1.33)	1.57 (1.31, 1.87)	1.22 (1.12, 1.33)
Rural	1.50 (1.22, 1.85)	1.09 (0.99, 1.21)	1.49 (1.21, 1.84)	1.06 (0.96, 1.17)

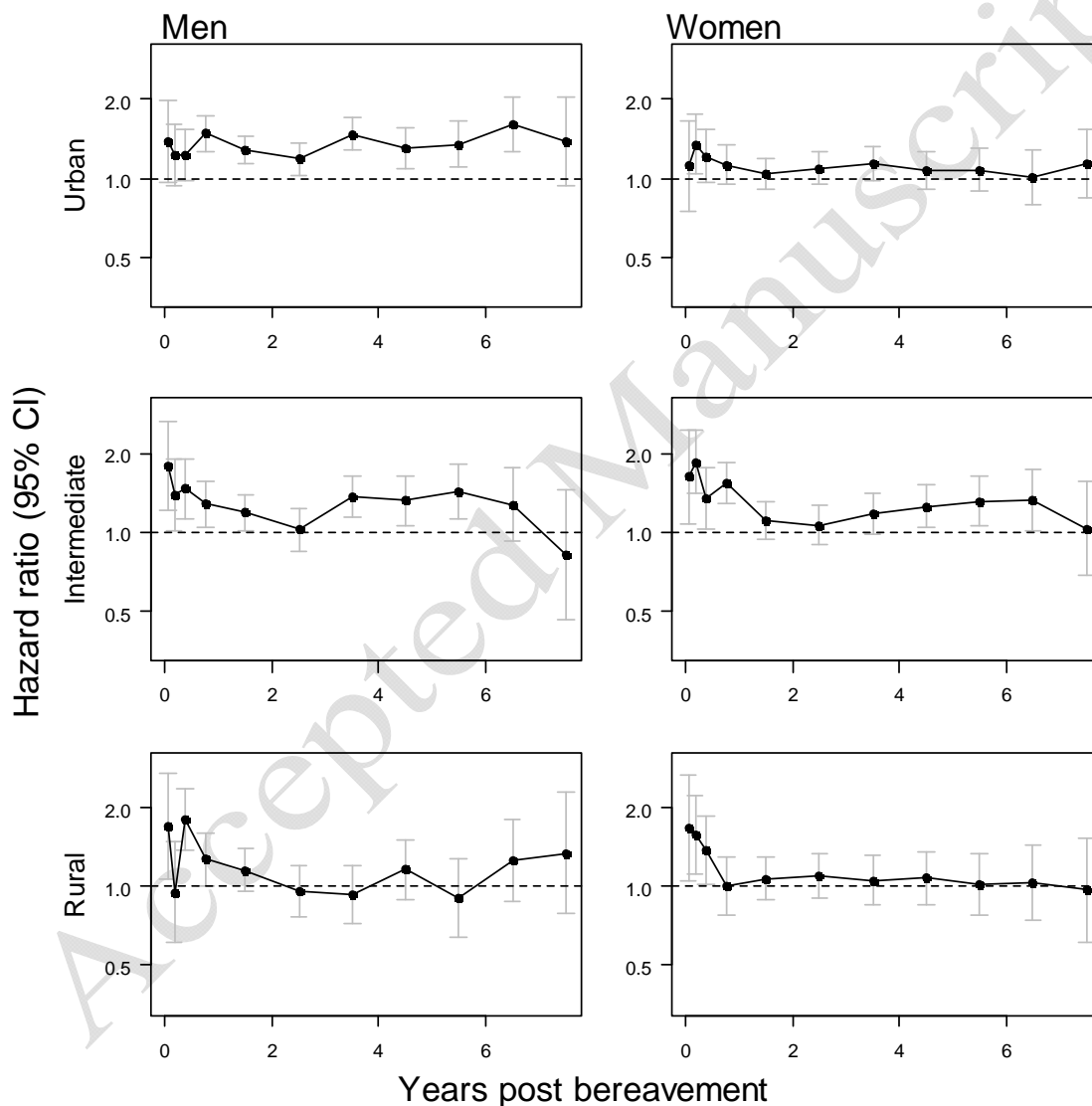
507

508 HRs and 95% CIs given for each group (compared with the non-widowed). Separate models
 509 fitted for each sex and rurality classification, adjusted for age, economic activity, social class,
 510 education, household size and car access, housing tenure, health status (general health and
 511 limiting long-term illness), presence of others in household (both dependent children and non-
 512 dependents), country of birth and religion.

513

514 **FIGURES**

515 **Figure 1.** Effect of time since bereavement (HR and 95% CIs) on hazard of mortality for
516 widowed people compared with those not widowed, Northern Ireland, 2001-2009. Separate
517 models fitted for each sex and rurality classification, adjusted for age, economic activity, social
518 class, education, household size and car access, housing tenure, health status (general health
519 and limiting long-term illness), presence of others in household (both dependent children and
520 other adults), country of birth and religion. First eight years of bereavement shown. Log scale.



521

522

523 **SUPPLEMENTARY MATERIAL**

Table S1. Proportion of couples living with other adults by settlement band, Northern Ireland, 2001.

	Couples	Living with other adults (%)
<i>Settlement band</i>		
A – Belfast	95 714	26.23
B – Derry	12 909	33.91
C – Large towns	39 100	26.69
D – Medium towns	16 943	27.35
E – Small towns	18 602	24.27
F – Intermediate settlements	12 458	25.00
G – Villages	12 307	26.53
H – Rural	88 092	32.20

524

525

Table S2. Effect of living with others adults on hazard of mortality by rurality, Northern Ireland, 2001-2009.

Rurality	Men		Women	
	HR	LRT interaction <i>P</i>	HR	LRT interaction <i>P</i>
Urban	1.10 (1.05, 1.15)	0.216	1.10 (1.03, 1.17)	0.464
Intermediate	1.12 (1.06, 1.18)	0.821	1.16 (1.08, 1.24)	0.654
Rural	1.11 (1.05, 1.17)	0.880	1.08 (1.00, 1.17)	0.117

527

528 HRs and 95% CIs given for each group (compared with those living with a spouse only).

529 Separate models fitted for each sex and rurality classification, adjusted for age, economic

530 activity, social class, education, household size and car access, housing tenure, health status

531 (general health and limiting long-term illness), presence of dependent children, country of birth

532 and religion. Likelihood ratio tests compared models in which the effect of living with others

533 was allowed to vary with stage of widowhood (< 6 months, ≥ 6 months) with models in which

534 there was no such interaction.

535