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The Places of Death: A Multilevel Analysis of 13,247 Couples in Dublin during the Demographic Transition

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1. Title Page

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2. Abstract

In many cities in the early twentieth century, one in five children still died before their fifth birthday. There is much we do not know about how these high death rates were reduced. This article investigates the mortality experiences of 13,247 families in Dublin City in the 1900s using a novel approach that incorporates geographic information systems, spatially-derived predictors and multilevel modelling (MLM). I find evidence of spatial correlations in mortality and a place-based migrant health advantage. After mapping over a thousand streets, mortality appears to have been highly uneven across urban space. Over 75 percent of this variation can be explained by the migrant share of streets. I also document large disparities in mortality between Jews and Christians, between higher and lower classes, and lower mortality among Catholics with Jewish neighbors. Jewish mothers were three to four times less likely to lose a child than Christian mothers. Detailed spatial data can rule out that living in more advantaged neighborhoods was a primary determinant of this advantage.

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3. Text

Introduction

Life-expectancies at birth have increased by thirty years over the last century (Cutler et al. 2006) and between the mid-19th century and World War I, life expectancies in many British cities rose by up to ten years (Szreter and Mooney 1998). The bulk of these gains were achieved through reductions in under-five mortality. The reduction in under-five mortality can account for almost 50 percent of the decline in the British death rate from 1901 and 1971 (McKeown et al. 1975, p. 395). Although this demographic transition transformed Western society, we know surprisingly little of how it was achieved (Reid et al. 2015). We believe that the construction of urban sanitation and water systems, improvements in housing, and the diffusion of information on health and hygiene were instrumental to lowering the death rate. Thus, spatial inequalities in health hold a key to understanding the mortality decline. Examining these processes helps us understand the past, while also informing policy aimed at tackling high mortality in present-day low-income countries. However, the lack of detailed spatial data on urban dwellers during the demographic transition obstructs attempts to describe intra-urban mortality patterns and to separate the effect of (dis)advantageous amenities from cultural influences, residential segregation and neighbourhood effects.

With this in mind, Dublin in the early-20th century provides an excellent case-site. New techniques and unique demographic data from the city permit a novel investigation into health inequalities between groups *and* across space. Even after improvements in health, the death rate in Britain's second city was double that of London or Edinburgh, with parents losing one in five young children on average (Christopher 1997; Grimshaw 1890). The infant and child mortality rates for the city hovered around 150 and 115 per thousand, respectively.[1]

As in other cities at this time, experts disagreed on whether high mortality in Dublin was the result of deficient Roman Catholic institutions and culture on the one side, or poverty and a range of structural factors on the other. Specifically, I ask: did high mortality in Dublin have its roots in behavioural differences between cultural groups or was it poverty and poor urban infrastructure? Contrary to the views of experts at the time, I find little evidence that culture accounted for the broad cleavages in mortality across the city. My results offer much stronger evidence for the importance of economic and housing characteristics. This paper broadly contributes to a new literature introducing detailed spatial data on mortality and environmental conditions to examine health inequalities during this period (Kesztenbaum and Rosenthal 2014; Reid et al. 2015; Thornton and Olson 2011; Alsan and Goldin 2015; Xu et al. 2014; Hanlon 2015).

At this time, disagreements over the effect of culture and infrastructure on public health were ongoing in London, New York and other major cities (see Brosco 1999). In his presidential address to the Royal Institute of Public Health in 1898, Charles Cameron (1898) argued that poverty, tenement housing, the underdeveloped sanitation system and the pollution of the city's air, waterways and streets, were responsible for high mortality in Dublin. In contrast, the Special Sanitary Commissioner of the medical journal, *The Lancet*, blamed Irish Catholicism and Roman Catholic institutions. The Commissioner argued that "the trouble in Dublin is not so much the organic defects in the system of domestic drainage as the filthy habits of the people" (The Lancet 1900, p. 199). The commissioner cited the "technical incapacity" of Roman Catholic teachers while reserving praise, as a counterpoint, for the Protestant missions in Dublin and the ablution and "lessons of cleanliness taught by the Mahommedan religion" (The Lancet 1899b; The Lancet 1900, p. 199). The Public Health Report also noted the better health of Jewish children in Dublin (Cameron 1901).

To examine these claims, I use a new dataset to analyse child mortality among 13,247 married couples resident on over a thousand streets in Dublin City in 1911. This dataset comprises the full non-institutionalized population of couples in the city who were married for less than fifteen years. I analyze individual and spatial variation in mortality using multilevel models and the geocoded locations of streets. Using this detailed individual-level data, I examine environmental and between-group differences in mortality while controlling for the residential segregation of Protestant, Jewish and non-native populations that lived disproportionately outside of the largely Roman Catholic and impoverished city center.

As mentioned, my results show that the claims made in *the Lancet* with respect to the influence of Catholic culture on health were exaggerated. Indeed, there *were* substantial differences in mortality between Catholics, Protestants and Jews. Relative to their Catholic counterparts, Protestant women experienced 30 percent fewer child deaths, while the mortality of Jewish children was three to four times lower (Figure 1B). But how much of this Catholic penalty can be attributed to strictly Catholic differences in behaviour? Up to three quarters of the gap between Catholic and Protestant mothers can be explained by "non-Catholic" factors including street characteristics, human capital and husbands' occupation.[2] Though mortality varied considerably across urban space and was higher on streets with more Catholics, this latter effect tends toward zero once the share of migrants living on each street is accounted for. Alone, the share of migrants explains 75 percent of the variation in mortality between streets. This suggests that non-Dubliners moved to neighborhoods that were conducive to better health. In sum, health disparities between Catholics and Protestants, and between migrants and non-migrants can largely be explained by standard economic and locational characteristics.

This said, I show that lower mortality among Jews (relative to Christians), the single largest mortality inequality in the city, cannot be explained by standard explanations of selective migration or between-group differences in fertility control, occupation, housing quality or proximity to infrastructure. In the 19th and early 20th century, lower infant and child death among Jews has been observed throughout Europe and North America (see Reid 1997; Preston and Haines 1991; Derosas 2003). These outcomes have been subject to a range of interpretations. I exploit the segregation of Dublin's Jewish population to examine whether or not spatial concentration is instrumental in these health outcomes. I show that only a negligible share of Jewish mortality outcomes can be explained by residential location. I also find evidence of spill-over effects for Catholics with Jewish neighbors.[3]

Overall, these results suggest that without detailed data on behaviours or social networks, the mechanisms underlying the Jewish mortality advantage will remain elusive. I conclude this paper with a discussion of qualitative data that suggests segregation and network externalities may have protected Jewish children from the hazards of 19th and early-20th century cities. These findings highlight the importance of ethnic distinctions in health and beneficial amplification effects for particularly at-risk neighbours.[4]

People, Places and Early-age Mortality

A sizeable urban mortality penalty arose in European cities during industrialization, before gradually falling over the 19th and 20th centuries (Woods and Woodward 1984; Woods 1985). Risk to infectious, airborne or respiratory diseases (e.g. bronchitis, pneumonia, influenza, whooping cough, scarlet fever, diphtheria and smallpox etc.), and food- and water-borne diseases (e.g. cholera, diarrhoea, dysentery) were heightened by overcrowding, poor quality housing and quickening disease transmission (Watterson 1986; Cliff et al. 1998). These episodic changes were so extreme during the second quarter of the nineteenth century that life expectancies in cities such as Glasgow, Liverpool and Manchester dropped to levels not seen since the Black Death in the fourteenth century (Szreter and Mooney, 1998; Szreter and Woolcock 2004a). Yet, even in the face of this rise and decline in mortality, inequalities in health were pronounced (see Reid 1997; Garrett et al. 2001)

The processes that generate spatial inequalities in health are not fully understood. Over 80 percent of Dublin's residents were Roman Catholic and native to the city. The poor health of this population was repeatedly contrasted with their Protestant, Irish- and Russian-born Jewish, and immigrant counterparts, living elsewhere in the city (Figure 4A). I exploit this residential heterogeneity to examine individual and neighborhood effects on early-age mortality. The literature offers three hypotheses for between-group differences in mortality: individual characteristics; differences in lifestyle or culture; and social isolation or segregation (van Poppel et al. 2002). Studies repeatedly show that individual characteristics including socioeconomic status, wages, demographic behaviours or genetic characteristics, cannot account for large inequalities or changes in mortality rates (Reid 1997; Woods et al. 1988 & 1989). This is supported by the Dublin data. Only among Catholics was there a visible economic gradient in mortality (Figure 1B). The role of culture and segregation are more difficult to dismiss.

Although few studies examine intra-urban mortality patterns, segregation is increasingly used to explain inequality in outcomes. Segregation influences health by limiting social contact between groups, increasing social contact within groups, and through the hoarding of urban amenities or resources. Using simulations, van Poppel et al. (2002) show that infection rates are lower for more isolated populations when intergroup contact is limited. They advance this as a possible explanation for health advantages among minorities including Jews and Mennonites. Thornton and Olson (2011) argue that such differences are driven and exacerbated by neighbourhood effects and own-group preferences in housing markets. The benefits of neighborhoods are tentatively supported by other recent evidence from Belfast that shows higher mortality among couples that move neighbourhood more often (Reid et al. 2015). Neighborhood advantages also appear to be "leaky." In this paper, I show results consistent with earlier findings: controlling for other factors, Catholics with Jewish neighbors experienced lower levels of mortality (see Ó Gráda 2004; Sawchuk et al. 2013).

Cultural interpretations of Jewish-Christian differences are prominent in the mortality literature but are difficult to test. Qualitative evidence suggests that Jews were fastidious in their health and relied more on medical literature and professional healthcare (Derosas, 2003; Goldstein et al. 1994). This includes austere habits such as bathing rituals, peculiarities in food preparation and the spacing of intercourse and births (Garrett et al. 2001; Ó Gráda 2006; Preston and Haines 1991; Reid 1997; Sawchuk et al. 1985). Perhaps the most important influence, but equally difficult to substantiate, are the immunological, nutritional and cleanliness benefits derived from later weaning (Woodbury 1926; van Poppel et al. 2002). A series of institutional and structural interpretations have also been offered. Most notably, Jews benefited from strong community support systems, lower levels of labor force participation among mothers and intergenerational experience with urban living (Marks 1994; Preston et al. 1994). The high social capital of Dublin's Jewish community has also been stressed (Ó Gráda, 2006). I later argue that network externalities are useful in interpreting different accounts of the Jewish mortality advantage.

The Disease Environment

This study focusses on Dublin City (Figure 2). This area is defined as the fifteen wards located between Dublin's Grand and Royal Canals (O'Brien 1982). In 1911, Dublin City was resident to 267,268 people. From this population, I extracted 13,247 couples for analysis. These couples were linked to 1,178 street midpoints using manual geocoding and data from Connor et al. (2011). Approximately 781 couples could not be located on historic maps. These missing addresses are not randomly distributed. Most missing streets were narrow courts and laneways concentrated in the impoverished city centre. This omission affected only the regression coefficients from the spatial regression models (Table 4) and do not adversely affect the conclusions of this article.

In the early 20th century, child mortality was higher in Dublin than in most British and European cities. In the previous century, residential inequality worsened as the city-centre became tenement-ridden and increasingly dominated by the largely Catholic working-class (see Daly 1984; Brady and Simms 2001; McManus 2002). In these places, blocked toilets, contaminated water, malnutrition, inadequate hygiene and damp walls heightened early-age mortality (Ó Gráda 2004). The 1914 housing report depicts the conditions of the time as it notes "it is no uncommon thing to find … houses in a filthy condition, and in nearly every case human excretia is to be found scattered about the yards … the closets and in some cases even in the passages of the house itself" (Dublin Housing Inquiry 1914, p. 5). Living conditions in Dublin were such that the city had more cases of typhoid and fewer cases of diphtheria than similar UK cities (O'Brien 1982). Typhoid fatalities were a marker of bad housing, occurred in tenements and were associated with contaminated water and impure milk.

The halving of infectious and communicable disease contagion from 1890 and 1916 occurred along with public health campaigns and improvements in housing and sanitation (O'Brien 1982). Dublin had arguably the worst slums in the UK. Though housing closures were frequent, evictees, affording rents of only one to two shillings per week, had few opportunities to secure better accommodation (Cameron 1898). To alleviate this crisis, public and philanthropic organizations undertook building programs to improve the housing stock. Though the city had been well supplied with clean water for decades, people in the poorest areas of Dublin continued to obtain their water from unhygienic public fountains (O'Brien 1982). Observers claimed to see drinking taps and fountains "surrounded with faecal matter" (The Lancet 1900 p. 159). The effects of water contamination were exacerbated by low rates of breastfeeding and the sale of unsafe milk. In response, the Women's National Health Association (WNHA) opened Dublin's only pasteurized milk depot in 1908. The contamination of water sources did not improve until the completion of a city-wide upgrade of the sewage removal system in 1906 (O'Brien 1982).

I examine the influence of environmental factors on mortality by exploiting variation in the distance of couples from urban (dis)amenities. Recent studies have examined spatial effects on mortality of water and sanitation systems (Kesztenbaum and Rosenthal 2014; Alsan and Goldin 2015), and street and air-borne pollution (Thornton and Olson 2011; Hanlon 2015). I construct five spatial variables for this analysis. First, I georeferenced the homes of all people (approximately 600) dying from typhoid from 1882-1887. I counted the number of fatalities within 200 meters of each street.[5] This measure serves as a proxy for housing quality and temporal persistence. Second, I calculated the distance of each street to the River Liffey. Contemporaries believed the River Liffey to be a public health hazard that was akin to a large open sewer (William Jenner 1880). Third, to investigate the effect of housing quality directly, I used street addresses to identify 324 couples living in the better-quality homes built by Dublin

Corporation and other philanthropic organizations.[6] Fourth, I identified all couples living in proximity to Dublin's only pasteurized milk depot. Finally, I used modern SRTM raster data to calculate the elevation of each street midpoint (Jarvis et al. 2008).

The Population of Interest

I constructed my sample using individual-level records from the 1911 census of Ireland. The registrar general was responsible for the 1911 census and relied on the police for enumeration. Each census form was completed and signed by the head of household and the enumerator then provided a summary report. This was the last census taken of the entire island. The next census taken was of the newly formed Irish Free State in 1926. Although the original records have been available since 1961, they have only recently been digitised. The digitised census files contain information as written on the A form. The A form includes questions on age, religion, place of birth, literacy, occupation, relationship to the head of household and marital status. The A form also includes questions regarding the number of children born and alive for each married woman in the household, as well as their total number of years married.

There were approximately 30,210 women in the 15-49 fertile age range that had given birth to at least one child in the 1911 census. I restricted the analysis to the currently married to exclude abandoned wives, widows and unmarried women. These women had unknown and systematically different fertility and mortality exposures. I paired household heads with their wives to construct 13,247 couples. I limited this sample to couples: less than fifteen years married; with at least one child ever born; with both husband and wife present on census night; and not resident in a workhouse, institution, barracks or hospital. Of the 42,537 children born to these couples, 34,198 were still alive.

I constructed the dependent variable using demographic methods that were developed to analyze mortality from retrospective reports. Retrospective reports of fertility and mortality are problematic because of endogeneity. Fertility and mortality are related to each other and can differ between cohorts. As a result, refined measures and indexes have been developed (see Garrett et al. 2001). Using lifetables, I standardized the proportion of children deceased to each mother using aggregate fertility and mortality information for the city. [7] Using these techniques of "indirect estimation", I produced an early-age mortality index that is standardised across the 0-4, 5-9 and 10-14 marital duration groups (Brass 1975; Garrett et al. 2001; Trussell 1975; United Nations 1983). This mortality index represents the actual number of children that have died to a mother, divided by the number expected to have done so within her marital duration group.

Aside from spatially-derived predictors (see above), I included a broad set of independent variables drawn directly from the census data (Table 1). Due to inconsistent reporting, these variables required a great deal of preparation. In this study, the religious denomination of the mother is a key variable. I categorized people as Roman Catholic, Protestant, Jewish or of Other Religion. Religious and ethnic categorizations disguise considerable intra-group heterogeneity and can reify inter-group boundaries (see, for related discussion for the 1910 US census, Watkins 1994). However, in the case of Dublin, inequalities between Catholics and non-Catholics were increasingly institutionalised and salient.

In all historical economic research, descriptions of occupations are difficult to analyse. Standardized classifications for occupations in historical Europe have been developed through the HISCO project and occupations have been quantitatively ranked as part of the HISCAM project (van Leeuwen, et al. 2002; Lambert et al. 2013).[8] I use the Irish adaption of these schemes, constructed by Fernihough et al. (2015), as my primary family-level economic indicator. I rely mainly on occupational classes rather than quantitative rankings of occupations (van Leeuwen and Maas 2011). This decision does not change the results of my regressions.

The deaths of children did not necessarily occur while their parents' lived at their 1911 place of residence. Residential mobility rates were high in British cities before World War I (Reid et al. 2015; Pooley 1979). To Justify my imputation of retrospective mortality events on these locations, I discuss locational change in Dublin. I use the linked 1901 and 1911 Irish census sample constructed by Connor (2015) to assess mobility across enumeration districts for men aged under 40. In separate analyses of the married and unmarried in Dublin City and Dublin County, I consistently find that 40 and 45 percent of men were located in the same enumeration district after ten years. This persistence rate is high for this period. Further, the focus on young men in Connor's sample suggests that this estimate of persistence is a lower-bound estimate. This finding is consistent with the conclusion of Reid et al. (2015) for Belfast: despite high rates of mobility, moves were typically over short distances. Along with the strong spatial correlations in Figure 3, this should allay fears over the effect of residential mobility on these results.

Estimation

My approach builds on recent urban research using historical census data and sophisticated statistical techniques to analyse segregation, and demographic and economic outcomes (see Spielman and Logan 2013; Xu et al. 2014; Clark et al. 2015). I estimated two sets of models to examine determinants of mortality in Dublin. First, I estimated multilevel models, by regressing the mortality index on the full battery of census-derived independent variables for all 13,247 couples. Second, I regressed the mortality index on these initial variables and also the spatially-derived variables for the subsample of 12,429 couples that were matched to street midpoints. Beyond these spatial variables, there are some slight differences in variable choice between the spatial and non-spatial models. Notably, in the spatial models I only modelled streets and not wards. Further, I modelled total population within 200 metres of the street instead of using the total population of the street.

Few studies have analysed historical early-age mortality using multilevel modelling. Multilevel analysis performs at least as well as classical OLS, reduces estimation errors and allowed for efficient modelling of geographic and individual-level variation (Gelman and Hill 2006, p. 246). I used the lme4 package in R and its associated materials for all modelling (Bates et al. 2015). To evaluate model fit I used a 'badness of fit statistic', the deviance information criterion (DIC), (Jones 2012). To aid interpretation I have also included the p-values which I estimated using the "lmerTest"' package (Kuznetsova et al. 2013). The p-values are calculated using log-likelihood ratio tests and F-tests, similar to those found in most statistical software packages.

Earlier research suggests that linear regression techniques *are* suitable for modelling the mortality index, which is highly skewed and bounded between zero and positive infinity. A Tobit model may better handle this skewness. However, a Tobit approach is considerably more difficult to interpret and to estimate in multilevel form. This approach would also obstructs comparisons with previous studies. Results also show little difference between Tobit and OLS models of the mortality index (Preston and Trussell 1982, p. 31; Garrett et al. 2001, p. 441-469).

Results

Dublin City was characterised by pronounced spatial and intergroup cleavages in infant and child mortality. Several axes of difference between couples can be identified: social class; religion or ethnicity; and place of residence. Although differences by occupational class were initially strong, these effects weakened once I controlled for religion and birth origin. Figure 1B shows that only among Catholics was there a steep occupational gradient in mortality. Mortality was also geographically uneven across the city (Figure 3). Much of this spatial variation can be explained by neighborhood characteristics including housing, and occupational and ethnic segregation. This said, the intra-street correlations in mortality in Table 2 are small. It is unsurprising that most of the variation in outcomes are at the level of the individual. Although many people are exposed to hazardous environments, only a small number of these people die as children. Table 2 also shows strong correlations at the individual-level between mortality and occupation, religious denomination, marriage timing and fertility.

I illustrate the geographic dimensions of mortality in four ways: modelling streets and wards in a multilevel hierarchy; mapping average mortality levels using Geographic Information Systems (GIS); modeling the compositional characteristics of streets (e.g. population size and ethnic composition); and modelling the proximity of streets to hazards or infrastructure. Dot plots with error bars are standard output from multilevel models. However, analyzing twelve hundred streets in this way is inefficient. GIS mapping is better suited for this task. Figure 3 shows variation in mortality between streets in different parts of the city. Streets in the centre and northeast of the city are characterized by high mortality. These places were largely inhabited by Dublin-born Catholics. The periphery was more heterogeneous and was home to fewer Catholics and more Protestants, Jews and migrants to the city (Figure 4A and 4B). I return to the effect of living in these areas below.

Though much between-street variation can be explained by individual characteristics, aggregate characteristics explain more. Table 2 shows that measures of occupational class and basic human capital can explain almost 50 percent of the mortality variation between streets within the same ward. However, the occupational ranking of the street, its Catholic share and its migrant share explain around 50 to 70 percent of this between-street variation. The explanatory power of these variables partly reflects unmeasured physical and environmental characteristics of streets (e.g. building quality, proximity to hazards).

Even after modeling individual-level characteristics and segregation measures, health enhancing infrastructure still shows beneficial effects in reducing mortality. Lower elevation, nearness to the River Liffey and proximity to earlier typhoid fatalities are all associated with higher mortality in Model 2.2 of Table 4 but tend toward zero once basic segregation measures are controlled for in Model 2.3. Table 5 shows strong positive effects on health from better quality housing and of living near a clean milk distributor. The coefficient for housing quality is commensurate in size with the difference between literate and illiterate people or between Protestants and Catholics. These are the only two spatial variables that do not tend toward zero once measures of social and economic segregation are incorporated into the model (Table 4, Model 2.3). It is also important to highlight the negligible effects of crowding that may be driven by measurement error.[9] The census data do not allow for the calculation of the footage or frontage of streets.

There are large differences in mortality between migrants, non-migrants and between religious denominations. The univariate coefficients show significantly higher mortality for Dubliners compared to non-Dubliners, particularly Russian-born immigrants (Appendix Table 2). However, Model 1.2 in Table 3 suggests religion to be the key division among those of different birth origin. The Jewish coefficient, and the concomitant disappearance of the Russian effect, suggests a Jewish rather than an immigrant advantage in mortality. Though people born in Britain experienced fewer child deaths than Dubliners, this can also be explained by differences in occupational class and fertility patterns between the two populations. Catholics and Jews had considerably higher fertility than their British and Protestant counterparts.

Low Jewish mortality is robust to the controls that explain most of the Catholic-Protestant mortality gap: the occupation of husband; place of residence; parity; and marriage timing. Inter- and intra-group differences in mortality between religious denominations are notable with respect to both economic status and parity (Figures 1A and 1B). In isolation, there appears to be little or no notable economic gradient in mortality among Protestants and Jews but large differences among Catholics. High status Catholics and Protestants experienced similar levels of mortality while there was considerable inequality in outcomes between their low status counterparts. Jews maintain their mortality advantage across all occupational ranks.

The relationship between mortality and parity is not surprising. Protestants were underrepresented among the City's working classes, and relative to their Catholic counterparts, Protestants with larger families lived in different places and could access better resources. However, in the models with all controls (Table 3, Model 1.5) and the models with street fixed-effects (Appendix Table 1), the Catholic-Protestant gap shrinks dramatically. In the fixed-effect models, the mortality difference between Catholics and Protestants is no longer statistically significant, dropping by over 70 percent when compared to the univariate models. The Jewish difference remains strong, at least some of which may be related to the marriage of Jews at healthier maternal ages (Figure 5).

I use cross-level interaction models to examine the differential effects of living in predominately Jewish or migrant neighborhoods. From these models, I arrive at opposing conclusions. Column 2 and 3 in Table 5 suggests that a form of neighbourhood or network effect operated in Jewish neighbourhoods. Mortality was generally lower for all residents living on more Jewish streets but the magnitude of this effect operates differently among Christians. Relative to Catholics, early-age Protestant mortality was higher on streets with greater shares of Jewish residents. Whatever the exact nature of the Jewish spill-over effect (e.g. the transmission of health behaviours or information), Catholics benefited more from living in these neighborhoods.

Columns 4 and 5 in Table 5 suggests that the large explanatory power of the migrant share variable is being driven by an omitted variable bias. The omitted variables likely relate to the disease environment, housing or unmeasured hazards such as pollution. If the migrant share coefficient represented a true segregation or clustering effect, we would expect at least some heterogeneity between migrants and non-migrants in these places. Instead, the models show almost no extra benefit for migrants living in more migrant-populated areas. This suggests that the migrant share effect is being driven by lower all-group mortality on the periphery of the city. Due to the non-random settlement of "healthier" minority populations in these places (see Figure 4B), it is an open question as to how much of this periphery advantage is driven by good environment and how much by the selective in-migration of healthier families. In either case, this finding tentatively challenges the claim that rural families moved to urban areas that were highly hazardous to health, in pursuit of work and higher wages.

Discussion & Conclusion

The role of culture in mortality and morbidity is still a hot topic in the low-income countries today. During the 2014 Ebola epidemic, cultural habits pertaining to hygiene, the consumption of particular types of meat, and ceremonial burial, were frequently used to explain contagion. A century ago in Dublin, commenters such as those writing in *the Lancet* (see above) also made extreme claims pertaining to the dangers posed by Catholic culture and behaviours. My results suggest that these claims were overstated. The relative gap between Catholics and Protestants fell by over 70 percent after controlling for occupational class, literacy and place of residence. This further underscores the need for vigilance when interpreting (even expert) claims about the role of culture in health.

This is the first study, known to the author, to analyse historical infant and child mortality in Europe using this methodology. Though these results are broadly consistent with earlier studies, this approach has yielded several new insights. Mortality appears to have been very uneven across urban space during the demographic transition. Though persistence is evident in the initial relationship between typhoid fatalities in the 1880s and child mortality in the 1900s, the effect disappears once measures of social and economic segregation were incorporated. This could reflect displacement of the working-class following improvements in housing and infrastructure in the intervening period, or simply urban change over time. The explanatory power of the migrant share is also notable and appears to operate as a proxy for better overall environmental health. This might be picking up the effects of industry and economic activity in the centre of Dublin (see Hanlon 2015). This raises two important question for future research. Why did young couples in Dublin choose to raise their children in the impoverished and hazardous city centre while migrants appear to have been intentionally avoiding these places? How much of a mortality penalty was experienced by families moving to cities? Answering these question would offer insight into how at-risk populations respond to local variation in risk-factors and improvements in urban amenities.

I have demonstrated that multilevel modelling is a flexible tool for analysing health inequalities within cities. The estimation of contextual effects offers insight into the interactions between individuals and their environments. These coefficients are easily exported for use with a GIS. Further, in cases where the use of fixed-effects are costly, multilevel modelling can be used as a substitute to avoid *type I* and inferential errors. There are also many excellent sources of historical spatial data such as the Grimshaw and Cameron (1988) map of typhoid fatalities. Often these data are superior to contemporary public data sources and could be useful in identification strategies. It is now relatively easy to geocode and link these data to administrative records. In the case of Ireland alone, there is a great deal of scope for research using the complete-count 1901 and 1911 Irish censuses. Valuable future projects might: use the samples constructed by Connor (2015) to examine internal migration and mortality; use the development of water and sewerage systems to examine class differences in health over time; or to construct social or kin networks using marriage registers.

This spatial analysis was not fruitful in explaining the Jewish-Christian mortality gap. However, these results strongly suggests that advantageous neighbourhood amenities can be ruled out as a major determinant. I argue that belonging to a spatial network may have been key to these outcomes. The concept of health by association in the context of nineteenth century Britain is not new (Smith and Lynch 2004; Szreter and Mooney 1998; Szreter and Woolcock 2004a; Szreter and Woolcock 2004b). The recurrence of social isolation, neighbourhood effects and segregation in the literature (van Poppel 2002; Derosas 2003; Ó Gráda 2006; Olson and Thornton 2011; Reid et al. 2015) suggests that spatial network externalities may have been at work (see Borjas 1995; DiMaggio and Garip 2011; DiMaggio and Garip 2012; Portes 2000 for discussions of ethnic externalities). Studies of Jewish communities outside of Ireland, and Ó Gráda's (2006) study of Jewish Dublin, are illuminating in the Jewish case.

It has been well noted that Jewish mothers, during this period, had "prolific" social networks (Marks 1994, p. 91). I argue that these networks lowered mortality through two pathways. Firstly, by helping the spread of health enhancing information between co-ethnics and second, through social pressures on network members that resulted in more effective behaviours. Through their networks, Jewish mothers received health enhancing information relating to childbearing, weaning children at older ages, bathing (*mikvah*), hand-washing, *kosher* food and the preparation of a *kosher* kitchen (Marks and Hilder 1997). These networks also provided access to information and obstetric care from doctors, paediatricians and Jewish midwives (*bobba)* (Goldstein et al. 1994). These behaviours and much of this knowledge predates the demographic transition. Jewish networks were particularly difficult to penetrate due to the variety of factors that resulted in high rates of endogamy, residential segregation, the speaking of Yiddish and generally low levels of social mixing (notably, not eating or working with Christians). Thus, these networks were effective at locking-in "old" information.

Information on health enhancing behaviours was more effective within Jewish communities for two reasons: deviating from norms would result in social reproach, and as van Poppel et al. discuss, lower levels of social contact with a "less healthy" population reduces contagion. The close observation of peers would strongly discourage deviations from beneficial behaviours such as late-weaning or food hygiene. How do we know that norm observance was particularly strong? Social control in Jewish communities has been emphasized since Durkheim's (1897) *Le suicide*. Durkheim highlighted the effect of social unity (network density) within ghettos (spatial density) on Jewish suicides (mortality outcomes). Evidence of social control in the Dublin community can be seen in the high endogamy rates that were enforced through intermarriage taboos. Social control is also suggested by the well-publicised case of the Jewish couple who committed suicide after being shamed for breaching the *Sabbath* (Ó Gráda 2006). One potential avenue to test this externality hypothesis would be to construct ethnic social network data using the witnesses on marriage registers. If linked to census data, a more direct examination of peer effects on health outcomes could be undertaken.

4. Notes

[1] The WHO reports present day under-5 mortality rates of 76 per thousand for low-income countries and 7 per thousand for high-income countries.

[2] Multilevel models yield an estimate 63 percent smaller than OLS while fixed-effects return a non-significant coefficient that is 74 percent lower than the base model.

[3] Sawchuk et al. (2013) and Ó Gráda (2004) have both found evidence of spatial amplification effects.

[4] See Kim, Collins, and Grineski (2014) for discussion of neighborhoods and the Hispanic-health paradox.

[5] Cameron and Grimshaw (1888) commissioned the Royal Engineers' Department to map these typhoid fatalities in order to ascertain the source of excess mortality in Dublin's Royal Barracks. The spatial occurrence of these deaths was also a function of population density. Thus, I attempt to control for population density by summing the population of streets within 200 meters of each street midpoint.

[6] Although information on the quality of all housing was collected in the 1911 census it has not been, indexed by the National Archives of Ireland.

[7] For consistency with earlier work, I used level 14 of the Coale and Demeny West model life table.

[8] The HISCAM index refers to the relative position within the stratification structure. Values approaching 100 correspond to the most prestigious occupations, and approaching 0 for the lowest. For more details see: http://www.camsis.stir.ac.uk/hiscam/

[9] Without a better measured variable for population density, it is difficult to make broader claims about the effects of crowding on mortality.

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6. Appendix

I investigated several sources of bias in constructing the sample. Many husbands erroneously answered or were assigned the fertility information of the wife. Where possible wives with blank fertility information were reassigned the values of their husbands. I analysed the distribution of missing values for the thirty five couples that did not state their number of years married, the sixty six that did not state their number of children born, and the 456 not stating their number still alive. For those missing responses on children born and years of marriage questions, there was overrepresentation among illiterates and husbands with lower class occupations, those likely to have higher rates of child mortality.

The ‘children alive’ question is more problematic. Younger couples with only one or two children ever born were far more likely to have missing values for this question. I suspect that young mothers who had lost all of their children answered this question with a blank instead of answering with a zero. For these cases, I assigned a zero value. Following this imputation, the distribution of remaining non-response was similar to other martial fertility variables and appears to have been randomly distributed. There was likely a small degree of error but this resulted in a considerable improvement on the bias that would have been introduced otherwise. Irrespective of this decision, the major results of this study remain consistent.

Three other notable issues pertain to those with missing spouses and maternal mortality. First, in the 1911 British and Irish census, some women may have intentionally misrepresented their marital status to avoid the stigma of illegitimate children; in other cases, women may have been erroneously classified as married. Others’ husbands may have been working or travelling on census night. Although this group is heterogeneous, evidence from Belfast suggests that fertility was lower and mortality was higher for married women with absent spouses (see Reid et al. 2015) and this finding is corroborated here for Dublin.

Second, the apparent high rate of residential mobility in Irish cities at this time (see Reid et al. 2015) offers justification to restrict the analysis to those married for fewer years. The fertility and mortality experiences of older couples are more likely to have occurred in different places than to the places in which they were enumerated in 1911. Third, the maternal mortality rate was in in the region of 35 and 60 per 1000 child births during this time in Britain (Chamberlain 2006). Due to this risk, women with worse maternal care and with more children are likely to be underrepresented in the 1911 census and in my analysis.

7. Tables

Table 1. Description of Variables

Variable	Description & Counts	Count	Mean	SD
Individual Variables				
Age	Age.		30.71	5.7
Age at Marriage	Age at Marriage.		23.4	4.6
Marital Fertility	The number of children born per year of marriage.		3.11	2.1
Hiscam Index	Quantified occupational standing.			
Hisclass (c) (Occupational Class)	Unskilled Workers Farmers and Farm workers Foremen and Skilled Workers Higher Managers and Professionals Lower managers and professionals, Clerical and sales Lower Skilled Workers	4,169 173 3,289 432 1944 3240		
Literacy (c)	Husband can read and write Wife can read and write	12,155 11,810		
Place of birth (c)	Dublin Ireland ROW Russia UK	8,962 3,392 110 117 666		
Religion (c)	Roman Catholic Jewish Other Religion Protestant	11,581 167 64 1,434		
Environmental Variables				
Proximity to River Liffey	Distance to the nearest point on the River Liffey (100 metre intervals)		758	433
Proximity to Milk Depot	Street is within 400 metres of the Arbour Hill milk depot in Arran Quay	614		
Proximity to previous typhoid fatalities	The number of typhoid fatalities from 1882-1887 within 200 metres of the street		8.73	6.5
Elevation Above Sea Level	Elevation derived from a digital elevation model.		14.1	6.6
Population within 200m of Street	The total population of the street and all other streets within 200 metres		3304	1764
Guinness, Corporation or DAD Housing	Housing constructed by Dublin Corporation and philanthropic organization. These were udentified using the street address.	332		
Median Occupational Score of Street	The median occupational score of the head of households for each street.		4.46	0.78
Migrant Share on Street	The proportion of people on the street who were born outside of Dublin.		0.25	0.13
Catholic Share on Street	The proportion of the street who identified as Catholic.		0.84	0.14
Population Street (s)	The total population of the street.		442.5	419

(c) = categorical variable (s) = standardized units

Table 2. OLS Variance Partitioning by Variable

	Variance			VPC	
	Residual σ_e^2	Street σ_{u0}^2	Ward σ_{v0}^2	Intra-street Correlation	Intra-ward Correlation
Full Null Model (13,247 obs.)	2.689	0.04	0.007	0.0172	0.0026
Age of Mother	2.675	0.045	0.008	0.0194	0.0029
Age at Marriage	2.69	0.038	0.007	0.0165	0.0026
Marital Fertility	2.679	0.038	0.007	0.0165	0.0026
Husband's Occ. Class (ref = Unskilled Workers)	2.685	0.023	0.006	0.0107	0.0022
Husband Can Read and Write	2.685	0.029	0.007	0.0132	0.0026
Wife Can Read and Write	2.688	0.025	0.006	0.0114	0.0022
Place of birth (ref = Dublin)	2.69	0.029	0.006	0.0128	0.0022
Religion (ref = Roman Catholic)	2.687	0.026	0.006	0.0118	0.0022
Median Occupational Score of Street	2.686	0.021	0.006	0.0100	0.0022
Guinness, Corporation or DAD Housing	2.689	0.039	0.007	0.0168	0.0026
Population Street (s)	2.688	0.039	0.007	0.0168	0.0026
Migrnat Share on Street	2.69	0.012	0.002	0.0052	0.0007
Catholic Share on Street	2.688	0.017	0.005	0.0081	0.0018
Spatial Model Null (12,429 obs.)	2.679	0.049		0.0180	
Elevation of Street (s)	2.678	0.045		0.0165	
Proximity to Earlier Typhoid Fatalities (s)	2.679	0.038		0.0140	
Population within 200m of Street (s)	2.682	0.039		0.0143	
Proximity to River Liffey (100m intervals)	2.676	0.044		0.0162	
Proximity to Pasteurized Milk Depot	2.680	0.048		0.0176	

(s) = standardized units

Table 3 Multilevel models using all couples

	Model 1.1	Model 1.2	Model 1.3	Model 1.4	Model 1.5
(Intercept)	1.61***	1.58***	1.59***	1.56***	1.54***
Literacy (ref = Cannot Read and Write)					
Husband Can Read and Write	-0.22***	-0.21***	-0.22***	-0.20***	-0.20***
Wife Can Read and Write	-0.23***	-0.23***	-0.21***	-0.20***	-0.20***
Occupation of Husband (ref = Unskilled Workers)					
Farmers and Farm workers	0.11	0.14	0.13	0.14	0.14
Foremen and Skilled Workers	-0.21***	-0.16***	-0.17***	-0.15***	-0.15***
Higher Managers and Professionals	-0.44***	-0.28**	-0.29***	-0.24**	-0.23**
Lower managers and professionals, Clerical and Sales	-0.18***	-0.05	-0.05	-0.02	-0.01
Lower Skilled Workers	-0.20***	-0.16***	-0.16***	-0.14***	-0.14***
Guinness, Corporation or DAD Housing	-0.16	-0.19	-0.19	-0.18	-0.17
Religion (ref = Roman Catholic)					
Jewish		-0.65**	-0.62**	-0.62**	-0.63**
Other Religion		0.08	0.03	0.02	0.03
Protestant		-0.13*	-0.12*	-0.12*	-0.12*
Proportion Catholic on Street		0.09***	0.07***	0.06**	0.03
Birthplace (ref = Dublin)					
Ireland		-0.03	-0.07	-0.06	-0.05
Rest of World		-0.14	-0.15	-0.14	-0.14
Russia		0.09	-0.04	-0.06	-0.06
Britain		-0.02	0.01	0.01	0.03
Age			0.05***	0.05***	0.05***
Age at Marriage			-0.04***	-0.04***	-0.04***
Marital Fertility			-0.07***	-0.07***	-0.07***
Median Occupational Score of Street				-0.04*	-0.03
Proportion Non-Dublin Born on Street					-0.05*
Total Population Street (s)					0.01
DIC	50698	50590	50312	50301	50282
Num. obs.	13247	13247	13247	13247	13247
Variance: Street.(Intercept)	0.02	0.01	0.01	0.01	0.01
Variance: Ward (Intercept)	0.01	0	0	0	0
Variance: Residual	2.68	2.67	2.62	2.62	2.62

(s) = standardized units ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 4 Multilevel Models using only geocoded couples

	Model 2.1	Model 2.2	Model 2.3	Model 2.4	Model 2.5
(Intercept)	1.16***	1.21***	1.11***	1.50***	1.52***
Elevation of Street (s)	-0.01**	-0.01	0	0	0
Proximity to earlier Typhoid Fatalities (s)	0.07**	0.05	0.01	0.01	0.02
Guinness, Corporation or DAD Housing	-0.23	-0.24*	-0.19	-0.16	-0.16
Population within 200m of Street (s)	0.03	0.04	0.01	0.01	0
Proximity to Milk Depot	-0.11	-0.17*	-0.09	-0.08	-0.09
Proximity to River Liffey (100m intervals)		-0.07*	-0.02	-0.01	-0.01
Median Occupational Score of Street			-0.04	-0.01	-0.01
Proportion Non-Dublin Born on Street			-0.10***	-0.9***	-0.08***
Proportion Catholic on Street			0.05*	0.02	0.01
<u>Literacy</u> (ref = Cannot Read and Write)					
Wife Can Read and Write				-0.14*	-0.15**
Husband Can Read and Write				-0.20***	-0.19**
<u>Occupation of Husband</u> (ref = Unskilled Workers)					
Farmers and Farm workers				0.12	0.11
Foremen and Skilled Workers				-0.12**	-0.14***
Higher Managers and Professionals				-0.21*	-0.22*
Lower managers and professionals, Clerical and Sales				0.01	0
Lower Skilled Workers				-0.13**	-0.13**
<u>Religion</u> (ref = Roman Catholic)					
Jewish				-0.78**	-0.75**
Other Religion				0.09	0.04
Protestant				-0.13*	-0.12*
<u>Birthplace</u> (ref = Dublin)					
Ireland				-0.01	-0.05
Rest of World				-0.08	-0.09
Russia				0.18	0.07
Britain				0.02	0.04
Age					0.04***
Age at Marriage					-0.04***
Marital Fertility					-0.08***
DIC	47625	47613	47513	47398	47138
Num. obs.	12429	12429	12429	12429	12429
Variance: Street.(Intercept)	0.03	0.03	0.01	0.01	0.01
Variance: Residual	2.68	2.68	2.67	2.67	2.61

(s) = standardized units ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 5. Interaction Regressions.

Column	1	2	3	4	5	6
Religion (ref = Roman Catholic)						
Jewish	-0.735***	-0.664**	-0.654**	-0.670***	-0.659***	-0.656***
	(0.161)	(0.208)	(0.207)	(0.132)	(0.133)	(0.132)
Other	-0.02	0.001	0.001	0.023	0.02	0.024
	(0.204)	(0.204)	(0.204)	(0.204)	(0.204)	(0.204)
Protestant	-0.193***	-0.197***	-0.206***	-0.130**	-0.125**	-0.128**
	(0.047)	(0.047)	(0.047)	(0.048)	(0.049)	(0.049)
Jewish Share (s)	-0.014	-0.042	-0.039			
	(0.018)	(0.027)	(0.027)			
Jewish x Jewish Share (s)		0.016	0.011			
		(0.041)	(0.04)			
Other x Jewish Share (s)		0.495	0.488			
		(0.27)	(0.27)			
Protestant x Jewish Share (s)		0.108*	0.108*			
		(0.049)	(0.048)			
Religion (ref = Dublin born)						
Migrant				-0.048	-0.041	-0.043
				(0.033)	(0.034)	(0.034)
Migrant Share (s)				-0.093***	-0.080***	-0.081***
				(0.017)	(0.021)	(0.021)
Migrant x Migrant Share (s)					-0.033	-0.032
					(0.031)	(0.031)
Model Type	Without Interaction	Multilevel Interaction	OLS Interaction	Without Interaction	Multilevel Interaction	OLS Interaction

(s) = standardized units $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Appendix Table 1. Regressions with Street Fixed Effects

	Model 1	Model 2	Model 3	Model 4	Model 5
(Intercept)	1.647***	0.290	0.257	0.257	0.257
	(0.055)	(1.636)	(1.619)	(1.619)	(1.619)
Literacy (ref = Cannot Read and Write)					
Husband Can Read and Write	-0.240***	-0.106	-0.119*	-0.119*	-0.119*
	(0.052)	(0.057)	(0.056)	(0.056)	(0.056)
Wife Can Read and Write	-0.244***	-0.208***	-0.190**	-0.190**	-0.190**
	(0.059)	(0.063)	(0.062)	(0.062)	(0.062)
Occupation of Husband (ref = Unskilled Workers)					
Farmers and Farm workers	0.095	0.201	0.182	0.182	0.182
	(0.127)	(0.137)	(0.135)	(0.135)	(0.135)
Foremen and Skilled Workers	-0.188***	-0.098*	-0.124**	-0.124**	-0.124**
	(0.040)	(0.043)	(0.043)	(0.043)	(0.043)
Higher Managers and Professionals	-0.360***	-0.217*	-0.228*	-0.228*	-0.228*
	(0.085)	(0.098)	(0.097)	(0.097)	(0.097)
Lower managers and professionals, Clerical and Sales	-0.118*	0.024	0.017	0.017	0.017
	(0.047)	(0.055)	(0.054)	(0.054)	(0.054)
Lower Skilled Workers	-0.181***	-0.131**	-0.131**	-0.131**	-0.131**
	(0.039)	(0.043)	(0.042)	(0.042)	(0.042)
Guinness, Corporation or DAD Housing	-0.153	0.869	0.800	0.800	0.800
	(0.092)	(1.685)	(1.668)	(1.668)	(1.668)
Religion (ref = Roman Catholic)					
Jewish	-0.788***	-0.733**	-0.713**	-0.713**	-0.713**
	(0.130)	(0.254)	(0.252)	(0.252)	(0.252)
Other Religion	0.014	0.115	0.072	0.072	0.072
	(0.206)	(0.218)	(0.216)	(0.216)	(0.216)
Protestant	-0.236***	-0.107	-0.094	-0.094	-0.094
	(0.047)	(0.057)	(0.056)	(0.056)	(0.056)
Birthplace (ref = Dublin)					
Ireland		0.015	-0.023	-0.023	-0.023
		(0.037)	(0.038)	(0.038)	(0.038)
Rest of World		-0.157	-0.153	-0.153	-0.153
		(0.168)	(0.166)	(0.166)	(0.166)
Russia		0.165	0.063	0.063	0.063
		(0.296)	(0.293)	(0.293)	(0.293)
Britain		0.020	0.042	0.042	0.042
		(0.078)	(0.077)	(0.077)	(0.077)
Age			0.058***	0.058***	0.058***
			(0.004)	(0.004)	(0.004)
Age at Marriage			-0.045***	-0.045***	-0.045***
			(0.005)	(0.005)	(0.005)
Marital Fertility			-0.079***	-0.079***	-0.079***
			(0.008)	(0.008)	(0.008)
Fixed Effects (Streets)	No	Yes	Yes	Yes	Yes
R^2	0.017	0.132	0.150	0.150	0.150
Adj. R^2	0.016	0.024	0.044	0.044	0.044

(s) = standardized units ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Appendix Table 2. Univariate Regressions

Variable	OLS *est.*	MLM *est.*
Individual		
Age of Mother	0.02***	0.02***
Age at Marriage	-0.01**	-0.01*
Marital Fertility	-0.05***	-0.05***
Husband's Occ. Class (ref = Unskilled Workers)	0.05	0.08
Farmers and Farm workers	-0.29***	-0.27***
Foremen and Skilled Workers	-0.53***	-0.51***
Higher Managers and Professionals	-0.27***	-0.24***
Lower managers and professionals, Clerical and sales	-0.27***	-0.26***
Lower Skilled Workers		
Literacy (ref = Cannot Read and Write)		
Husband Can Read and Write	-0.44***	-0.41***
Wife Can Read and Write	-0.41***	-0.38***
Place of birth (ref = Dublin)		
Ireland	-0.13***	-0.10**
ROW	-0.34*	-0.31*
Russia	-0.69***	-0.68***
UK	-0.30***	-0.25***
Religion (ref = Roman Catholic)		
Jewish	-0.74***	-0.75***
Other Religion	-0.00	0.02
Protestant	-0.33***	-0.30***
Median Occupational Score of Street	-0.15***	-0.15***
Guinness, Corporation or DAD Housing	-0.18*	-0.21
Population Street (s)	0.03*	0.04**
Migrant Share on Street	-0.18***	-0.17***
Catholic Share on Street	0.16***	0.15***
Elevation of Street (s)	-0.08***	-0.08***
Proximity to Previous Typhoid Fatalities (s)	0.11***	0.10***
Population within 200m of Street (s)	0.09***	0.09***
Proximity to River Liffey (100m intervals)	-0.11***	-0.10***
Proximity to Pasteurized Milk Depot	-0.15*	-0.14

(s) = standardized units

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

8. Figure and Table Captions

Table 2. This table shows the variance partitioning for univariate multilevel regression models. The residual column shows the variance between couples living on the same street, the street column shows the variance between streets in the same ward and the ward column show variance between all words. The univariate regressions shows the explained variance of each individual variable at each level. Looking at the variance explained by the "Migrnat Share on Street" variable, we see a residual variance of 0.12. Relative to the "Full Null Model" which has a residual variance of 0.4, the "Migrant Share on Street" variable explains approximately 70 percent of the variance between streets in the same ward.

Table 3. Regression Results. The largest coefficient in size is between Jews and Roman Catholics. This value fluctuates when different levels of the life tables are used for the mortality index but the general results remain the same. Estimated differences between Jews and Roman Catholics ranged from approximately -0.6 to -0.8.

Table 5. Interaction Regressions. Controls include age, age at marriage, marital fertility, literacy and occupation. Multilevel model includes street random intercepts.

Figure 1A. Fertility and Mortality. Fertility and mortality are positively related for Catholics, Protestants and Jews. Confidence interval bands are calculated at the 95 percent level. These predictions are from a linear model with controls with basic demographic characteristics.

Figure 1B. Occupational Status and Mortality. The downward slope for Catholics in figure 2a suggests a strong occupational gradient in mortality among Catholics. The lines for Jews and Protestants appear to have a slightly positive slope. This is likely the result of small samples sizes at the extremes. Confidence interval bands are calculated at the 95 percent level. These predictions are from a linear model with basic demographic characteristics.

Figure 2. Mortality in Dublin Wards (1911). Random effect extracted from the null-model for Dublin wards. Base map from Thom's Directory of Ireland, 1910 edition (source: Glucksman Map Library, Trinity College Dublin).

Figure 3. Mortality on Dublin streets (1911). Random effects extracted from the null model for Dublin streets. There is a tendency for streets with lower mortality to be located closer to the periphery while streets with higher mortality tend to be in the city-centre and north-east. The map is sparse in some areas as I have omitted streets of average mortality (range: -0.1 to 0.1) to avoid cluttering. The shading of the River Liffey element corresponds to mean mortality among all people living within 200 metres of each segment of the river (buffers not shown).Base map from Thom's Directory of Ireland, 1910 (source: Glucksman Map Library, Trinity College Dublin).

Figure 4A. Proportions of Jews and Protestants on Dublin streets (1911). High concentrations of Protestants tended to be distributed around the periphery of the city, Jewish residential clustering was more confined to the area known as “Little Jerusalem” along the South Circular Road while Roman Catholics (not shown) lived throughout the city but heavily concentrated in the centre and northeast. The shading of the River Liffey element corresponds to mean mortality among all people living within 200 metres of each segment of the river (buffers not shown). Base map from Thom's Directory of Ireland, 1910 edition (source: Glucksman Map Library, Trinity College Dublin).

Figure 4B. Migrants in Dublin on Dublin streets (1911). Points correspond to streets with populations for which over 50 percent of people were born outside of Dublin. The ellipses highlight areas which contain the highest concentrations of high mortality streets (figure 3) but low concentrations of non-Dubliners. The shading of the River Liffey element corresponds to mean mortality among all people living within 200 metres of each segment of the river (buffers not shown).

Figure 5. Age at marriage of mother by religion in Dublin (1911). Protestants tend to marry slightly later than Roman Catholics. Jewish ages at marriage are skewed considerably more than both toward their early 20s.

9. Figures

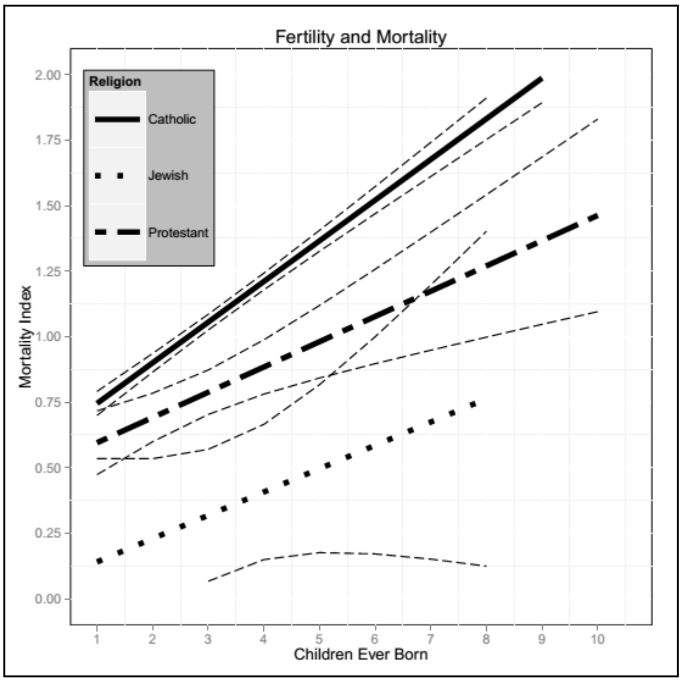

Figure 1A. Fertility and Mortality

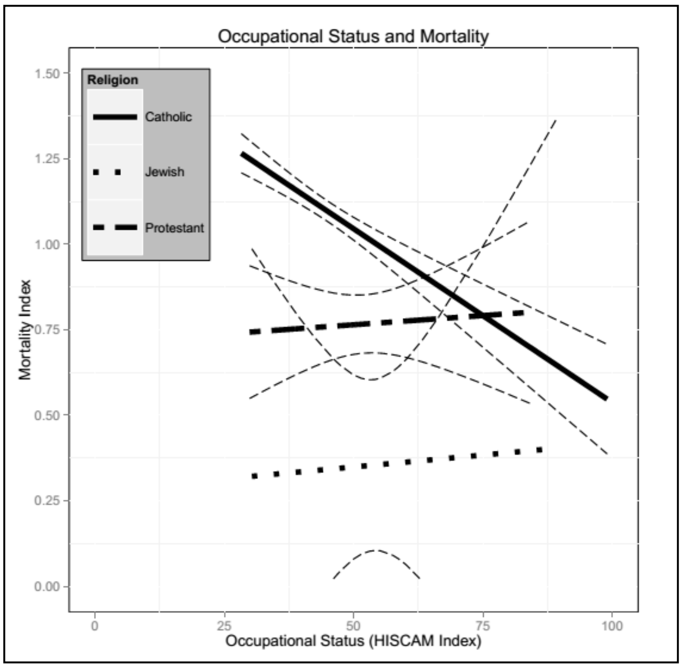

Figure 1B. Occupational Status and Mortality

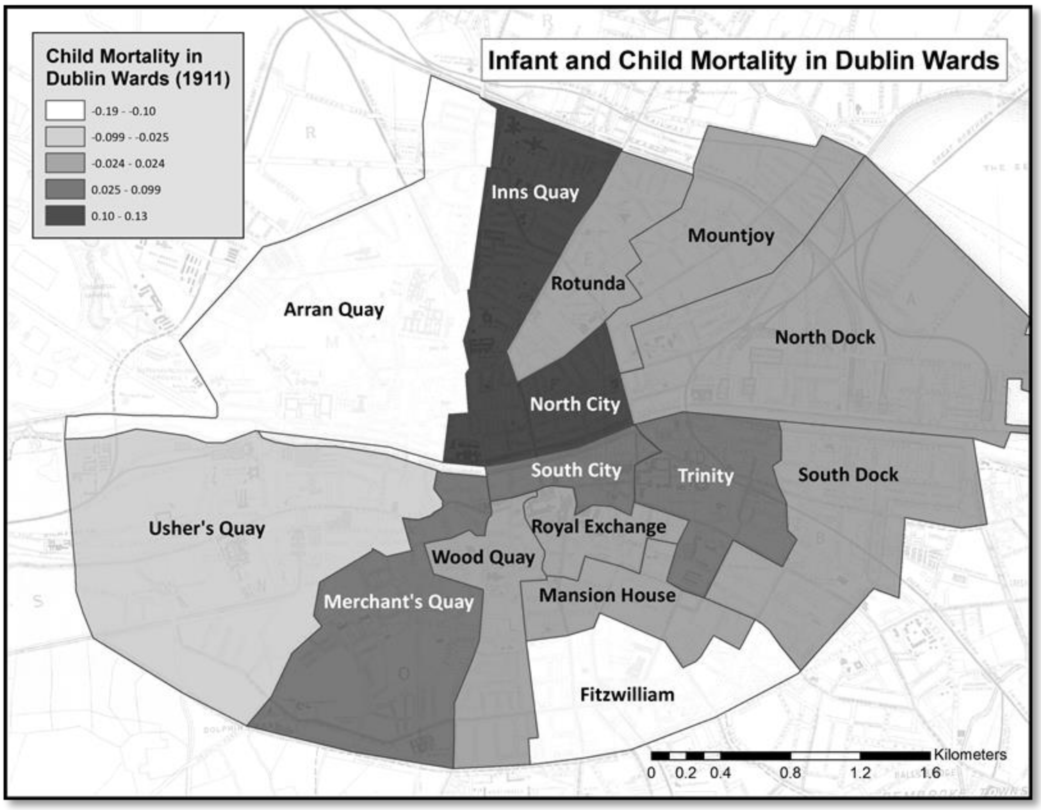

Figure 2. Infant and Child Mortality in Dublin Wards

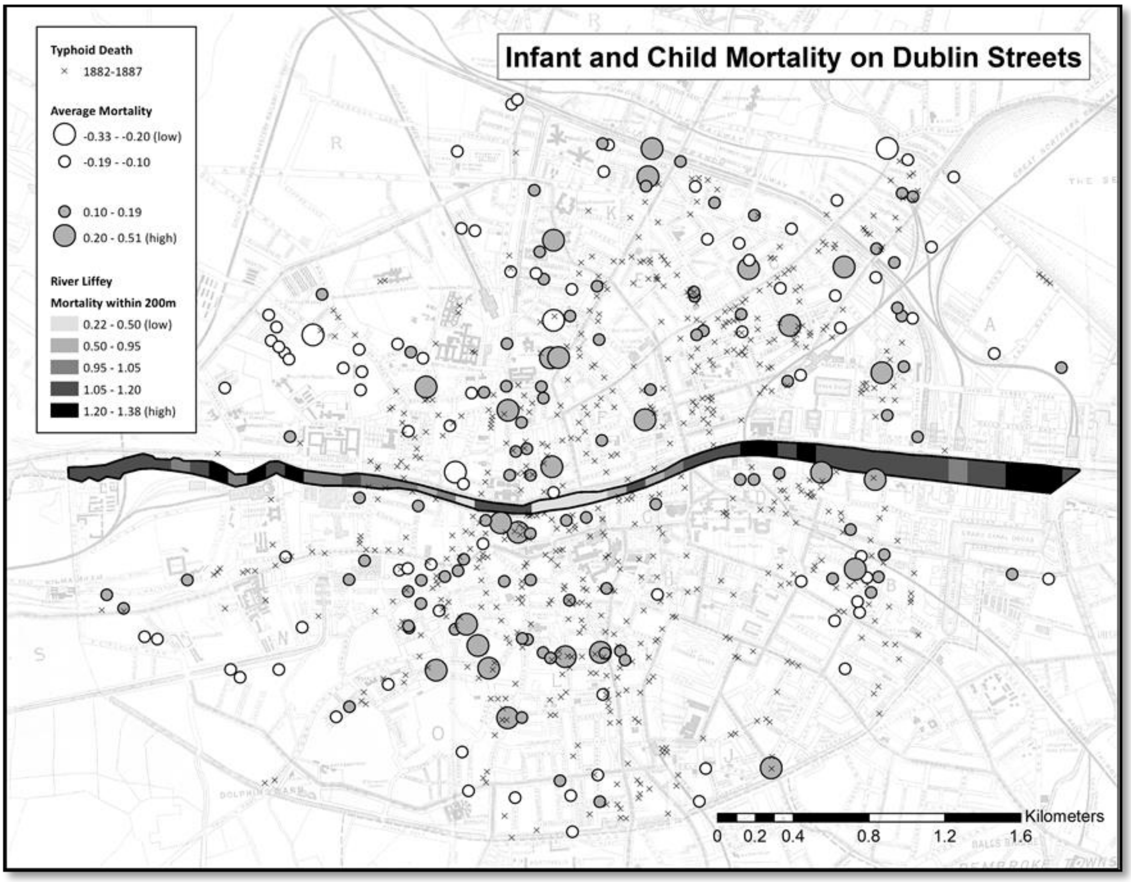

Figure 3. Infant and Child Mortality on Dublin Streets

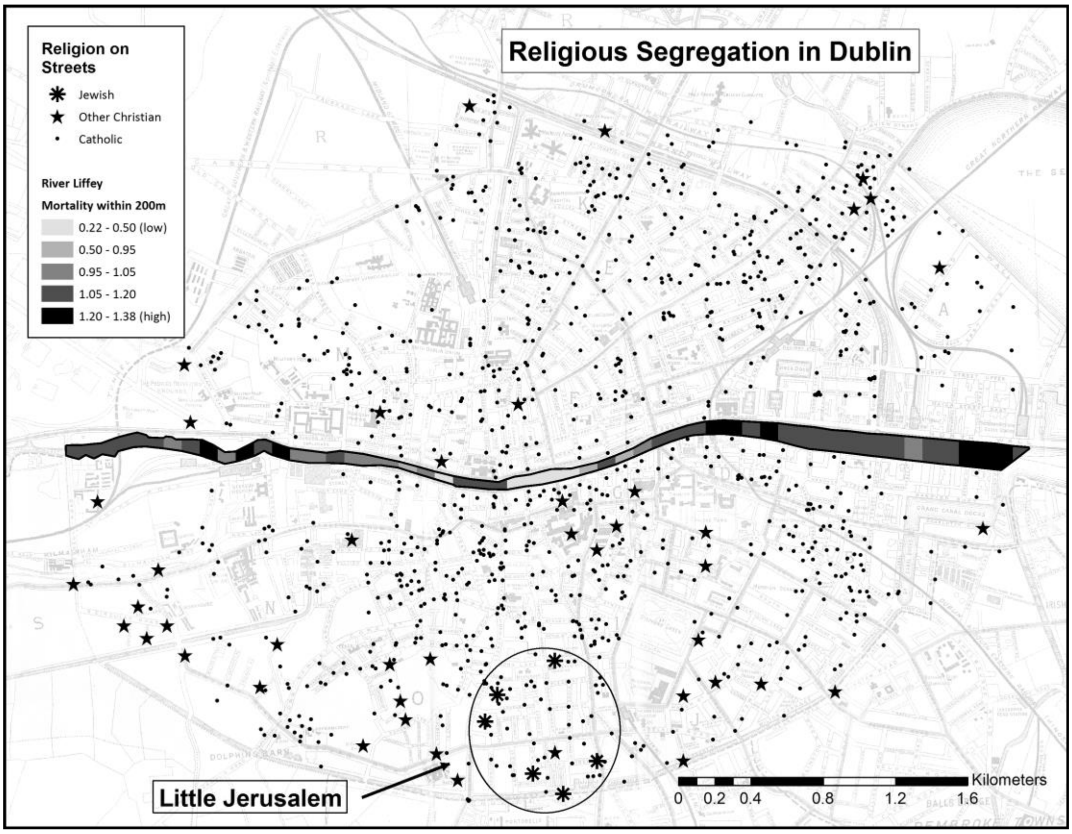

Figure 4A. Religious Segregation in Dublin

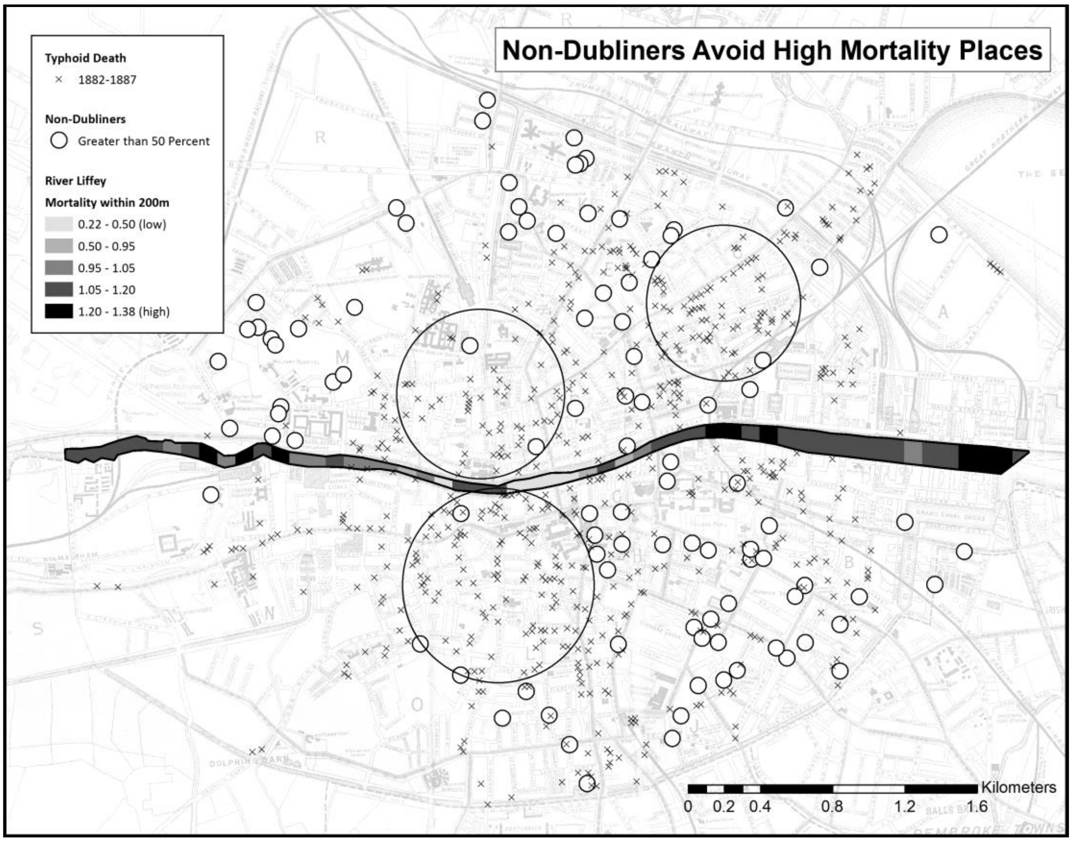

Figure 4B. Non-Dubliners Avoid High Mortality Places

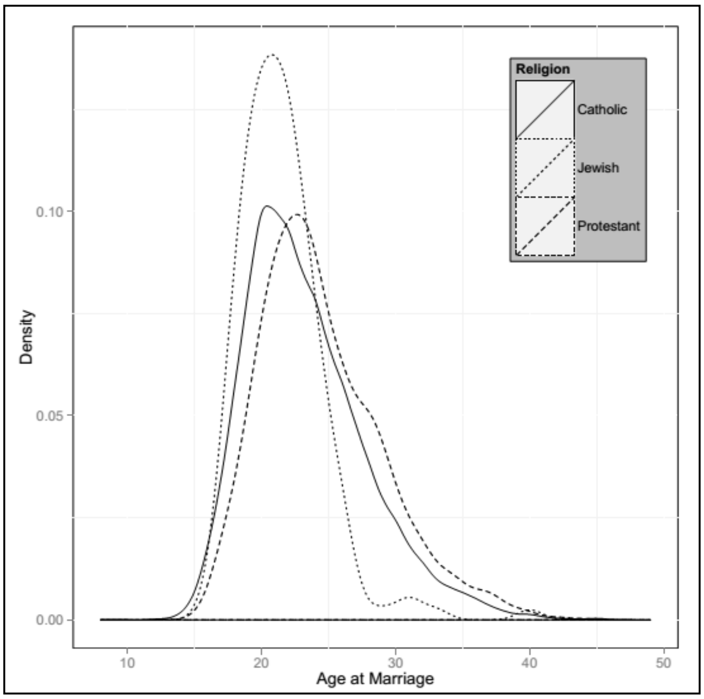

Figure 5. Age at Marriage