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2. **Abstract.** [150-200 words]

This paper argues that an understanding of the human cost of the Troubles in Northern Ireland is vital in the context of Brexit. This human cost is manifest in all-cause mortality records for the country, which in this paper are explored visually using level plots. A model is developed which formalises a key intuition developed through exploring the data, in which excess deaths in young adult males are represented by a component with a peak intensity in 1972, which then gradually reduces over many years. We call this an initiation-decay model, and based on it estimate the Troubles to have cost nearly 3000 lives, close to estimates produced by meticulously aggregating conflict-related deaths, and calculate an intensity 'half-life' of nearly seven years. We argue by reference to the political and social history of Northern Ireland that the conditions may still be in place in Northern Ireland for a further wave of conflict to be initiated, and thus that Brexit negotiations need to be very cautious in its approach to the region and the land border separating it from the EU.

3. (Video Abstract)
4. 3-6 **keywords**.

Brexit; Northern Ireland; Mortality; Troubles; Data Visualisation

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No potential conflict of interest was reported by the authors.

7. **Biographical note.** [up to 100 words]

Jon Minton is a researcher based in the School of Social & Political Sciences at the University of Glasgow. His primary research interest is in the applications of complex data visualisation approaches to exploring and understanding patterns in population data.

8. **Geolocation information.**

Scotland, UK

9. **Supplemental online material.**

The code used to produce the analyses presented here are available at the following location: https://github.com/JonMinton/Northern_Ireland_Troubles

Manuscript

Introduction

The issue of Northern Ireland, the Republic of Ireland, and the long border separating the two countries received relatively little attention in the run up to the EU Referendum on 23 June 2016. When the results of the Referendum were clear, and the Irish border became the only land border between the UK and the EU, Northern Ireland and the Republic of Ireland still received relatively little public or political attention. When, in the three months before the 2016 General Election, there were three terrorist events on the UK mainland, Northern Ireland still received relatively little attention in relation either to Brexit or UK government more generally, despite the region for many decades being one of Western Europe's fulmination points for terrorist-related activity. However, at the time of writing (13 June 2016), in the days following the General Election results, mainland attention has finally turned to Northern Ireland, given the critical role that the Democratic Unionist Party (DUP) may play in supporting a Conservative minority government, and the ramifications of Tory-DUP unions to stability both in Westminster and in the island of Ireland. This paper argues that more attention should have been paid throughout to Northern Ireland, and for a deeper analysis and understanding of the causes and consequences of violent conflict in the region.

Three specific empirical aims of this paper are: to use demographic data to visually illustrate the 'excess deaths' that appear attributable to the initiation of violent conflict in the early 1970s; to produce a number of estimates of total numbers of excess deaths attributable to the conflict, based on observed patterns and trends in overall mortality, and compare these with estimates based on deaths directly attributed to violence; and to characterise the particular pattern of excess mortality observed in Northern Irish demographic data, and describe why this is consistent with a tit-for-tat form of sectarian conflict.

Substantively, we argue that the fundamentals which led to this earlier wave of death and instability may still be present within Northern Irish society, and that poorly handled Brexit negotiations risk reinitiating a fresh wave of violence that, once started, may take decades to settle down again. The logic of our model challenges a dominant narrative about the peace process in Northern Ireland, suggesting that key political events in the road to peace followed rather than led trends towards reduced violence in the region.

In section two we will provide a brief history of the origins of Northern Ireland as a distinctly administered political territory, of the events which led to an initiation of violence in the early 1970s, and of key events and trends in violence and peace which occurred in the decades since. Section three will introduce the data and methods used to explore the impact of the Troubles on mortality patterns in Northern Ireland. Section four will present descriptive data visualisation and predicted mortality surfaces from the model, and estimates of total excess mortality associated with the conflict. Finally, section five, the discussion, will begin by comparing my estimates of conflict-attributable mortality with extant estimates of conflict-attributable deaths; then conclude with a discussion of political, sociological and social psychological literature which may shed light on the patterns uncovered, before highlighting a number of critical pitfalls that Westminster should be mindful of in Brexit negotiations to reduce the risk of a new initiation of conflict in the region.

Ireland, Northern Ireland, and the Troubles

The mathematical ecologist turned historian Peter Turchin has argued that one of the central challenges in the establishment and maintenance of complex, large, hierarchical societies – states and empires – is the promotion of social cohesiveness across ethnic groups. Turchin thus suggests that complex societies can emerge only once *metaethnic* communities, in which group membership can be readily identified through 'symbolic markers', have been established and agreed upon. Turchin states that the "most commonly used kind of symbolic marker to delineate metaethnic communities is religion – particularly, the exclusive, proselytizing kinds such as Christianity or Islam." (Turchin & Gavrilets, 2009) [p. 181] Common metaethnic identity allows for greater within-group cohesiveness and for the assimilation of otherwise ethnically heterogeneous populations, but where distinct and mutually exclusive metaethnic groups are territorially contiguous, metaethnic frontiers form, and at these frontiers competition and conflict between societies is often intense. Catholic religion pre-existed Protestantism, began in Southern Europe, and spread north and west, including to Ireland at Europe's western periphery. Protestantism then emerged later, from Northern Europe, and spread south and west. The conditions for a metaethnic frontier in the island of Ireland, demarcated along Catholic-Protestant religious distinction, were thus centuries in the making.

Within the political organs of Ireland under the British Empire - an imperious, expansionist state united by Protestant identity - positions for Catholics were limited, and there were concerns amongst British imperialists that Ireland could be used as a cultural and potentially military 'back door' through which the Catholic Empires could undermine British imperial power and influence. Ireland thus held an ambivalent position within the British Empire, geographically proximate yet culturally distant, a 'colony within the core'. Many of the patterns of political control and population management developed in the case of Ireland formed a blueprint for later British colonialism. (Anderson & O'Dowd, 2007)

The Great Famine of the 1840s led to mass emigration and population decline. By the end of the 19th century the demography and economy of Ireland had shifted to the North East of the island, in particular to the city of Belfast, and the populist Protestant Orange Order had emerged in response to increasing political agitation from Catholic populations for improved voting rights and the return of Irish Home Rule. The backlash to Home Rule from Ulster Unionists led to the establishment of paramilitary organisations by both sides, and a period of civil war which continued with the Great War of 1914, and culminated in the Easter Rising of 1916, in which fifteen Irish nationalists launched a failed coup attempt and were executed. In 1918 Sinn Féin were elected with more than three quarters of Irish seats in Westminster, civil war intensified, and the paramilitary Irish Republican Army (IRA) fought a guerrilla war into the 1920s. Ireland was partitioned, and a truce was established in 1921. The majority Protestant 'Southern Ireland' renamed itself the 'Irish Free State' and became an independent state in 1922, leading also to the formation of Northern Ireland in that year as a distinct administrative geography, which voted against Home Rule and to remain a British territory.

(Anderson & O'Dowd, 2007) summarise the legacy of the establishment of the Northern Irish border as follows:

> Under one-party unionist rule for 50 years, Northern Ireland proved to be the most problematic legacy of partition. It provided a 'cage' for two communal blocs locked into a mutually antagonistic and self-reproducing relationship with each other. The sizeable nationalist minority – initially a third of its population but threatening to erode unionism's 'safe' majority – was the main loser, disaffected and permanently excluded from state power. The majority unionist bloc maximised its micro-territorial control within Northern Ireland, but it retained endemic fears of being undermined by nationalist population growth, and/or physical attacks on partition, and/or being 'sold out' by British governments. […] The eruption of ethno-national violence a half-century after partition was part of the imperial legacy. [p. 947]

In the late 1960s a Catholic protest movement emerged, inspired by the civil rights' movement in the United States, prompting an often violent Protestant counter-movement opposed to Catholic marches, leading to widespread clashes between sides. Such clashes could not be controlled by the police forces, and the British Army were mobilised. The IRA was conflicted in its response to both the Army presence and Protestant reprisals, and in 1969 split into the less-militant Official IRA (OIRA), and the more militant Provisional IRA (PIRA). The Army, the OIRA and the PIRA competed to win favour and appear legitimate from the perspective of Catholic communities. Army attempts to disarm Catholic communities, combined with a lack of success defending them, further acted to delegitimise the Army amongst affected Catholic communities. The PIRA then began attacking the Army in 1971, and internment swiftly followed, leading to protests in which 23 people died; army troop numbers increased, and PIRA bombings and killings intensified. After internment, amity then further increased through the deployment and actions of the Parachute Regiment ('the Paras'), who faced a 7,000-strong Catholic civil rights march on 13 January 1972, 'Bloody Sunday', and shot dead 14 people later found to be unarmed. This event, more than any other, can be seen to have ignited the decades of sectarian conflict that followed. (Gerike et al., 2016; Thornton, 2007)

Data and Methods

Data on all-cause mortality and population size, disaggregated by gender, age in single years and year, were extracted from the Human Mortality Database (HMD). (University of California, 2017) Mortality rates were calculated by dividing death counts by population exposure (adjusted population counts). All data management and analyses were performed using the R statistical programming environment. (R Core Team, 2016)

In the first stage of the analysis, mortality rates by age and year were explored visually using level plots in which each column is a different year, each row a different age, and each cell is a mortality rate or log mortality rate for a specific combination of year and age in single years. This arrangement is known as a Lexis surface. (Jonathan Minton, 2014; Vaupel, Wang, Andreev, & Yashin, 1997)

In the second stage of the analysis, level plots for males aged between 15 and 45 years inclusive were produced. This gender and age range was focused on as a mortality pattern that appears attributable to the conflict post 1972 appears very clearly for this group, whereas in females and males at other ages no similar pattern is apparent.

In the third stage of the analysis, a model was developed which aims to reproduce the main features of the level plot of mortality values over this Lexis surface, in which conflict-attributable pattern of excess deaths is modelled as a separate variable. The final model specification was developed by comparing the penalised model fit of different model specifications using AIC and BIC, as well as the root mean square (RMS) error, and by visually exploring both the Lexis surfaces of predicted values, and of residuals (differences between predicted and actual values) to assess whether the model appears to capture the most salient features of the Lexis surface of the data itself. (Akaike, 1974)

The model specification is as follows:

$$l_i(t) = \beta_{0,i}^{(P)} + \beta_{1,i}^{(P)} t^{(P)} + \beta_{2,i} T(t)$$

$$T(t) = (1-k)^{(t-1972)} \; IFF \; t \geq 1972; 0 \; otherwise$$

Where $l_i(t)$ indicates the log_{10} mortality rate for males of age i in year t, the superscript (P) indicates which of three distinct phases in mortality improvement to which year t belongs, and $t^{(P)}$ indicates the number of years since the start of the mortality improvement phase to which year t belongs. The three mortality improvement phases, identified through visual exploration of the Lexis surfaces, are: Phase One: 1922 to 1938 inclusive; Phase Two: 1939 to 1955 inclusive; and Phase Three: 1956 and later. Within these three phases, the rate of age specific mortality improvement tended to be greatest in Phase Two (1939 to 1955), despite this period including World War Two.

$T(t)$ is the function which models the mortality effect of the conflict. It assumes that the additional mortality effect is greatest in the first year of the conflict, then decays exponentially with each subsequent year. The rate of decay in additional mortality is modelled using the parameter k, and can have any value from 0 to 1 inclusive. In the fourth phase of the analysis, numerical optimisation is used to select k such that AIC (penalised model fit) is minimised. Given k, the 'half life' of the conflict, i.e. number of years it takes for the additional log mortality risk to fall by half, can also be calculated using the formula $\lambda_{1/2} = \frac{\log(\frac{1}{2})}{\log(1-k)}$.

Finally, in the fifth phase of the analysis, the numbers of deaths at each age and in each year are estimated by applying the model's predicted mortality risks to the populations exposed to these risks, i.e. $D_i^A(t) = 10^{l_i^A(t)} p_i(t)$, where $D_i^A(t)$ is the number of deaths at age i and in year t under the active conflict scenario A, and $p_i(t)$ indicates the size of the population at this age and in this year exposed to the mortality risk. A counterfactual surface of risks $D_i^C(t)$ is modelled by setting $T(t)$ to 0 in all years. The total number of conflict-attributable deaths estimated by the model in this age range is then the sum of differences in deaths estimated under both scenarios, i.e.

$\sum_{i=15}^{45} \sum_{t=1922}^{2013} [D_i^A(t) - D_i^C(t)]$.

Results

Visual exploration of patterns

Figure 1 shows the Lexis surfaces of $\log_{10}$ mortality rates for both genders and for each age between newborns and 90 years. Cells are coloured according to mortality rate. The legend on the right show which colours correspond to which mortality values. The values on this legend indicate the 'number of zeros' associated with the mortality risk, with ranges from 10^0 or 1.0 risk for light blue at the top, then to 10^{-1} (one in ten) for lighter green shades, 10^{-2} (one-in-100) for lighter reds, to 10^{-5} (one in a million) for the brown shade at the bottom of the scale.

Figure 2 provides a stylised 'pen portrait' of some of the main features seen in figure 1. As with in many other countries, there is a much sharper increase in mortality risk once males reach adulthood, not observed to the same extent in female. In more recent years this can be seen by noting that for males almost all purple cells are seen in childhood, with cells at older ages coloured light or dark orange. This broadly corresponds to somewhere between half an order of magnitude, to a full order of magnitude, increase in mortality risk after males reach adulthood compared with their risks in childhood. By contrast for females the difference in colour and shade in early adulthood is much less different to in childhood.

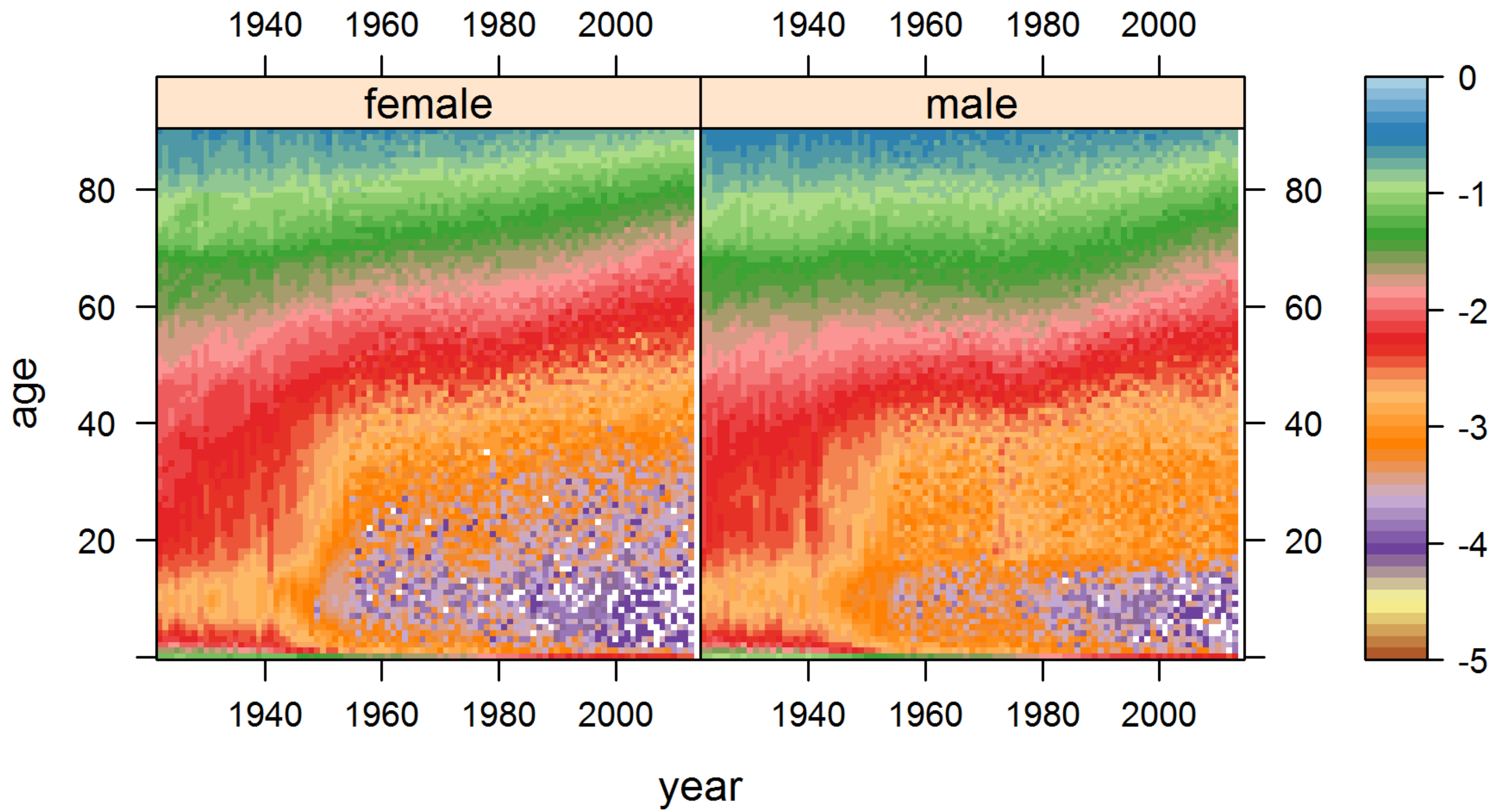

Figure 1: Levelplot of $\log_{10}$ mortality rates for males and females in Northern Ireland, 1922 to 2013. Cell colour indicates mortality risk. White cells indicate missing data. (Source: Human Mortality Database)

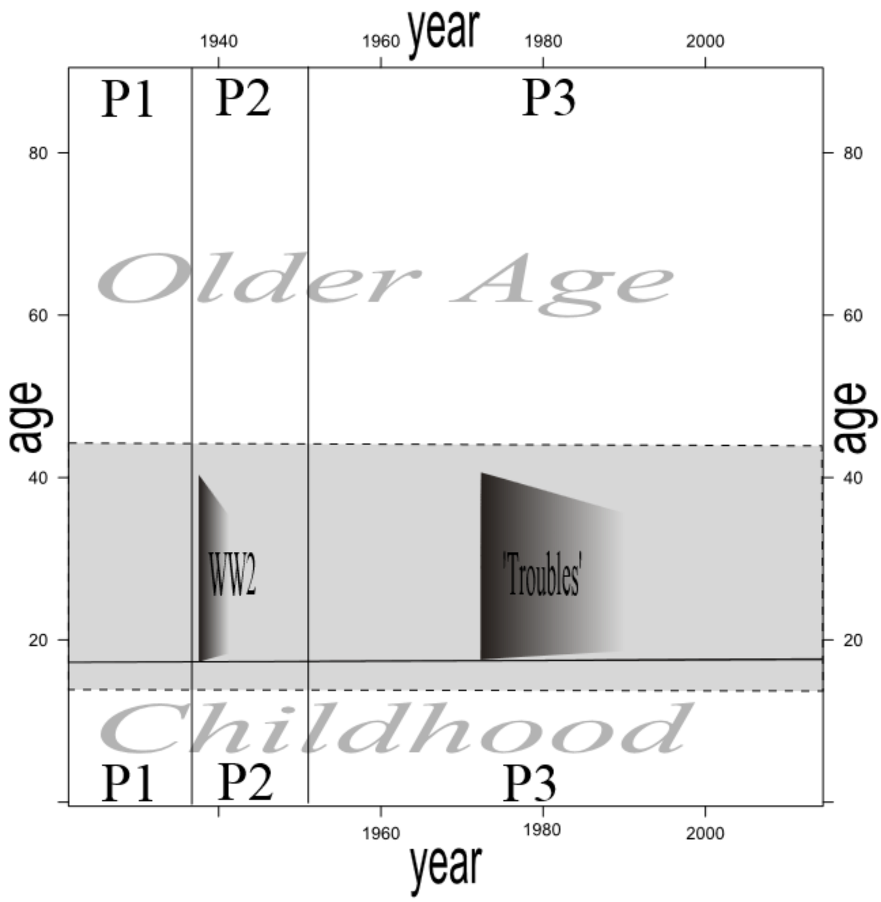

Figure 2: 'Pen Portrait' of key features in Figure 1.

Within Figure 2 P1, P2 and P3 indicate 'Phase 1', 'Phase 2' and 'Phase 3', each demarcating periods of years in which there appeared to be systemic differences in the rate of change in mortality risk at different ages. The much more rapid falls in both female and male young adult mortality over Phase Two is evident in the Figure 1 levelplot by noting that most of the cells in the age range 20 to 40 years are red before the late 1930s, whereas during this Phase they turn dark and light orange. This represents close to an order of magnitude fall in mortality risk at these ages over these years. This is despite the period including World War Two, indicated with a shaded polygon in Figure 2.

The effect of the Troubles on mortality is evident by noting the faint vertical band of red cells which appears in the male level plot from around age 18 to 40 after the early 1970s. Before this red band appeared cells tended to be a darker orange shade (slightly under a 1-in-100 risk), and a slightly lighter orange/yellow shade after. No similar discontinuity at this age range after the early 1970s is evident for females. Figure 3 explores this pattern further, by plotting the number of deaths for males and females aged between 18 and 40 years. A grey band is added indicating the years 1971-1973. Male deaths risk in 1971 and 1972, peak in 1973, and then remain above those seen in earlier years for many years afterwards; no similar increase is seen for females. The Troubles had a longer term effect than WW2 on male mortality.

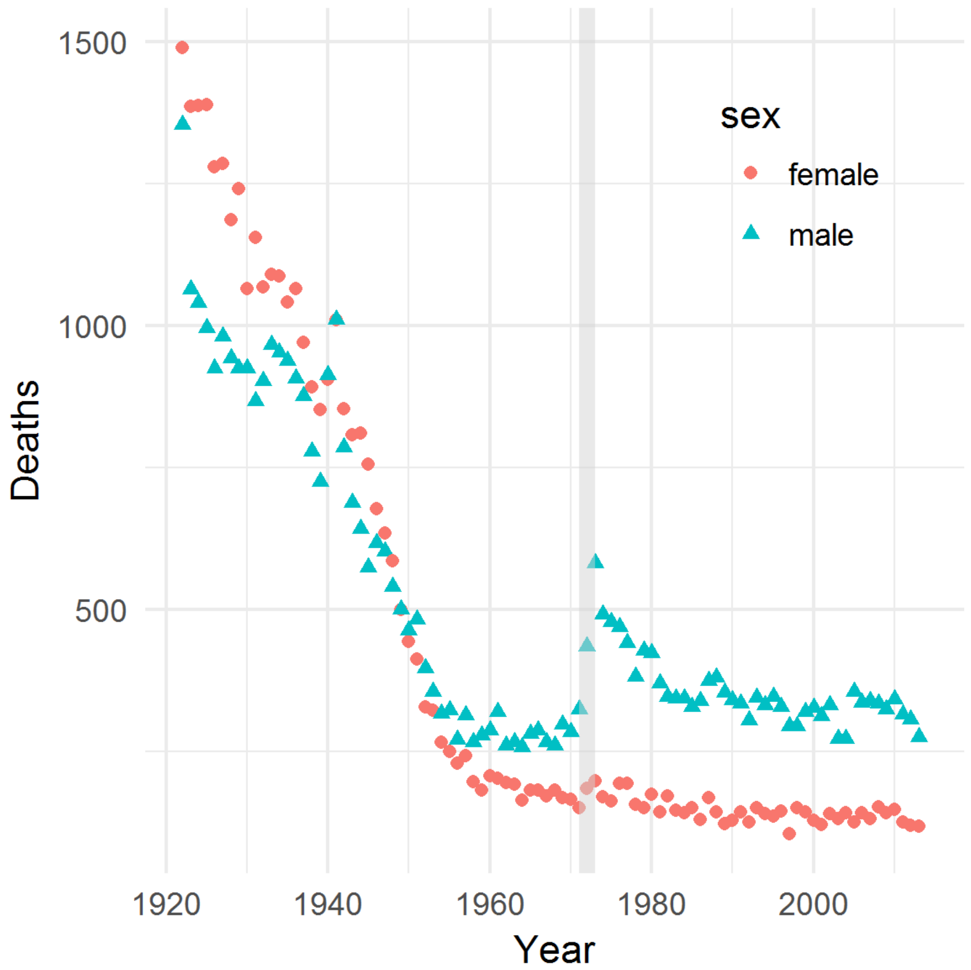

Figure 3: Deaths for males and females between the ages of 18 and 40 years in Northern Ireland. Grey band indicates the years 1971-1973

Within Figure 2, the large horizontal grey band indicates the age range 15 to 45 years, within which further analyses will focus. Figure 4 shows level plots for males and females for this age range only, using a slightly different colour scheme and range of $\log_{10}$ mortality values to before. Within this plot the effect of the Troubles on male mortality is clearer, and appears as a band of light red, then dark red, cells after the early 1970s after orange and dark red cells in earlier years. Again, no similar pattern is seen for females. The disruption to earlier trends for males appears mainly to affect males once they have reached adulthood, and to be sharpest at younger adult ages, from around the ages of 18 to 21 years of age.

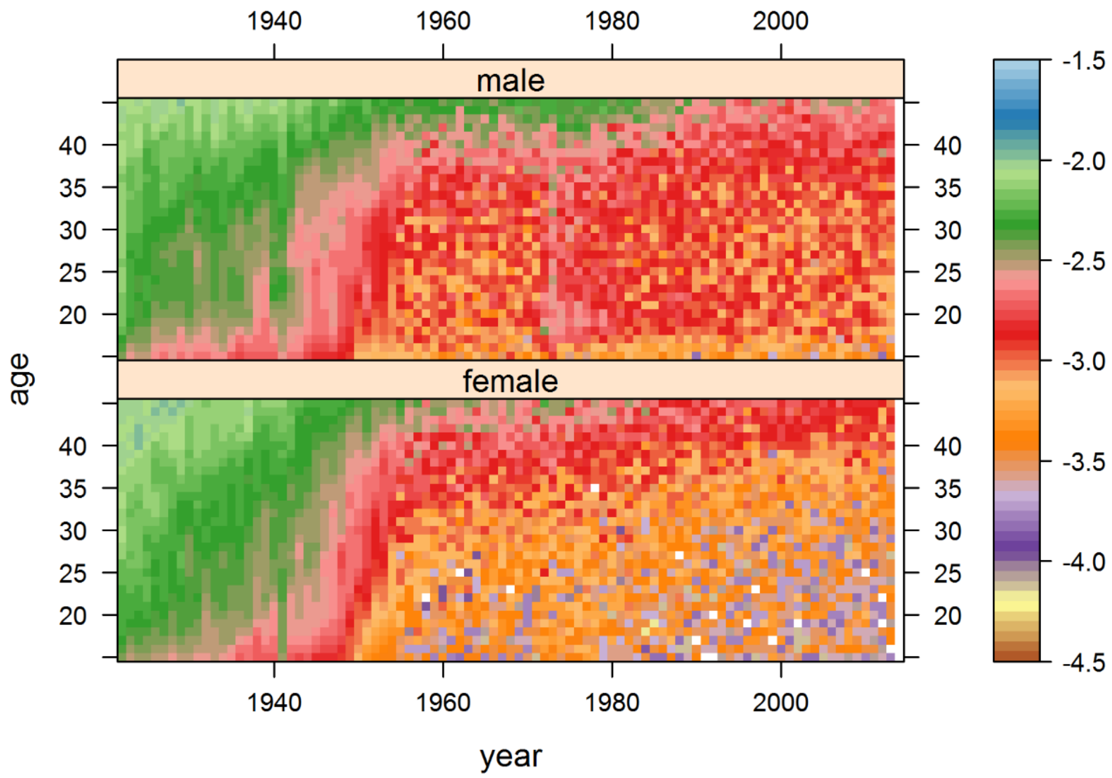

Figure 4: Level plot for log10 death rates for males and females between the ages of 15 and 45 years in Northern Ireland 1922-2013.

Modelling

Figure 5 comprises three rows, each presenting a $\log_{10}$ mortality surface for males over the age range 15 to 40 years and for all years. On the top row, labelled 'predicted', the model predicted surface, including the parameter for the Troubles, is presented; on the middle row, labelled 'counterfactual', the model prediction for a counterfactual scenario, in which the Troubles term is not applied, is presented; and in the bottom row, labelled 'actual', the actual $\log_{10}$ mortality values from the data are presented. We can see that the model is relatively effective at capturing the broad pattern and features of the actual surface, though is clearly and necessarily a somewhat stylised representation of the actual data surface.

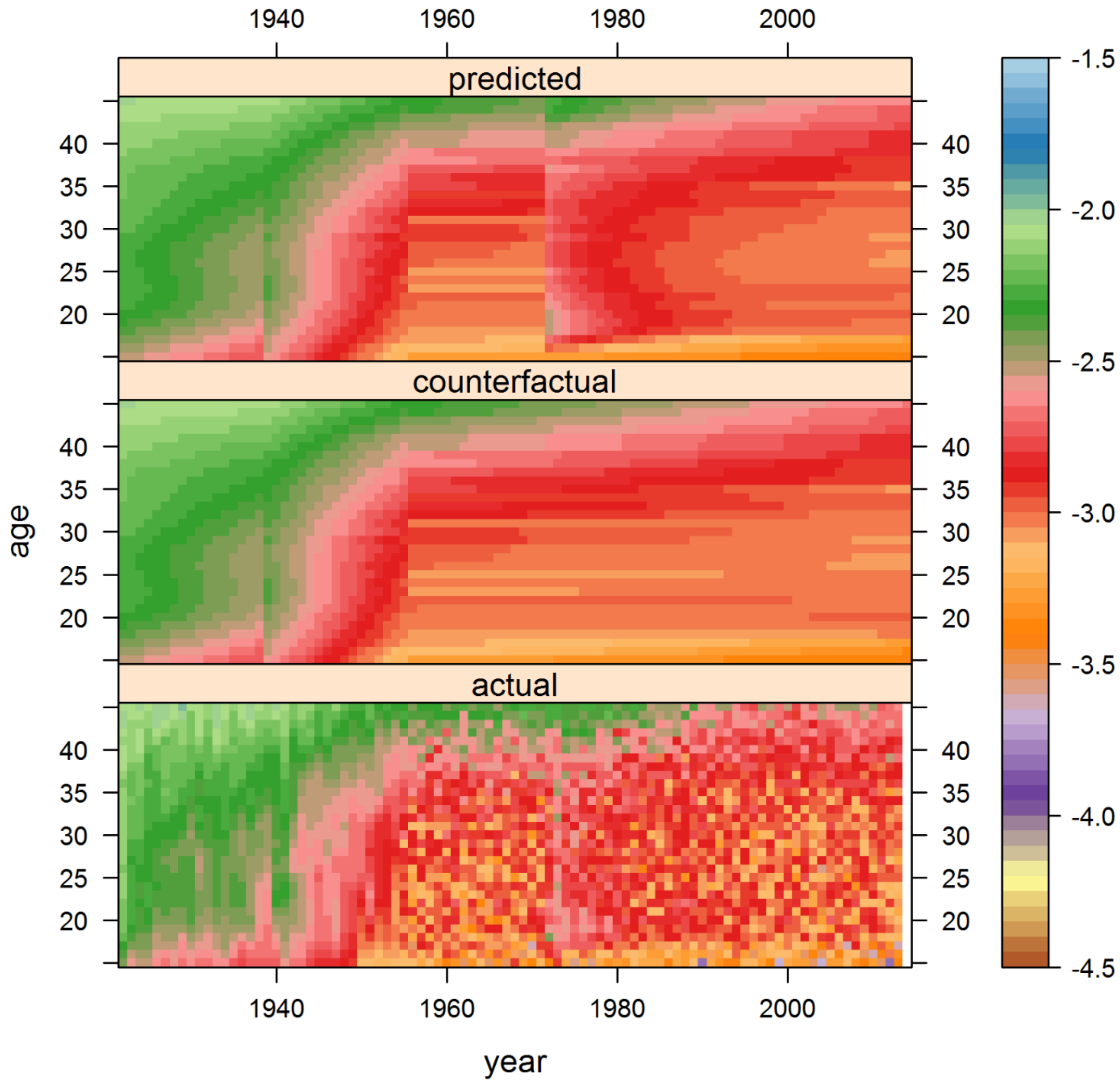

Figure 5: Level plots for modelled death rates (top row), modelled counterfactual death rates (middle row) and actual death rates for males aged 15-45 years in Northern Ireland, 1922-2013

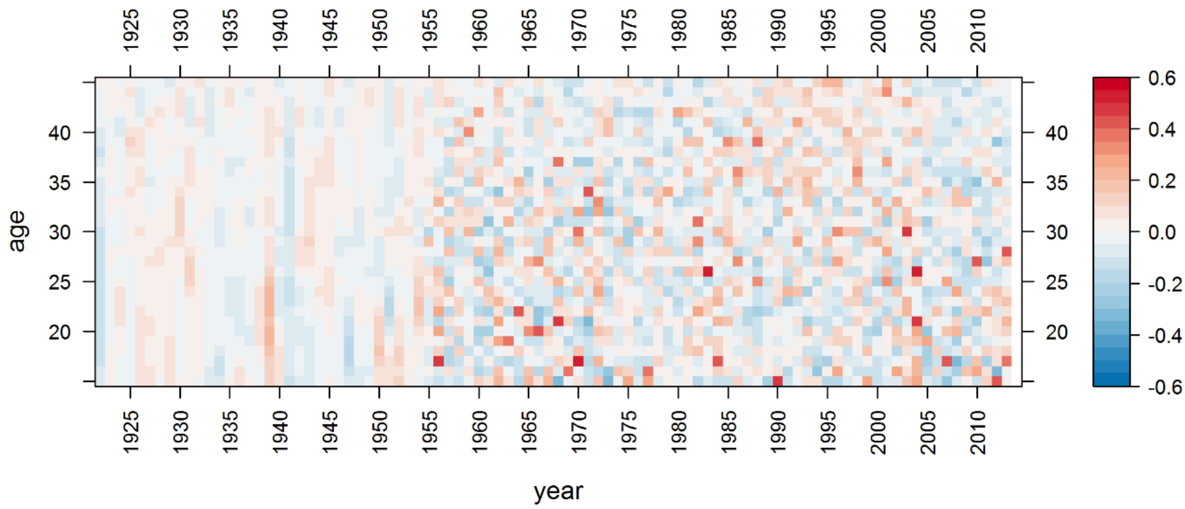

Figure 6: Level plots of residuals between modelled and actual log10 death rates by age and year for males 15 to 45 years in Northern Ireland, 1922-2013. Red indicates model overestimation, blue underestimation, and shade magnitude of error

Systemic bias in over-estimation or under-estimation of age-year specific mortality risks can be explored by looking at the surface of residuals between the predicted and actual surfaces, as shown in Figure 6: within this figure red cells indicate model over-estimation, blue cells under-estimation, and the shade of cells the magnitude of error. Systemic biases in these estimates appear as large 'patches' of cells with positive or negative residuals, as well as discontinuities in the data. There is a vertical band of red cells at younger ages in 1939; suggesting the model underestimates deaths in younger males during World War Two; this should not be surprising given the model does not include any terms to represent this event. Figure 7 shows the model fit as a function of the decay rate, k. The model has a best fit when k is 9.748%, suggesting a half-life of the Troubles of 6.76 years.

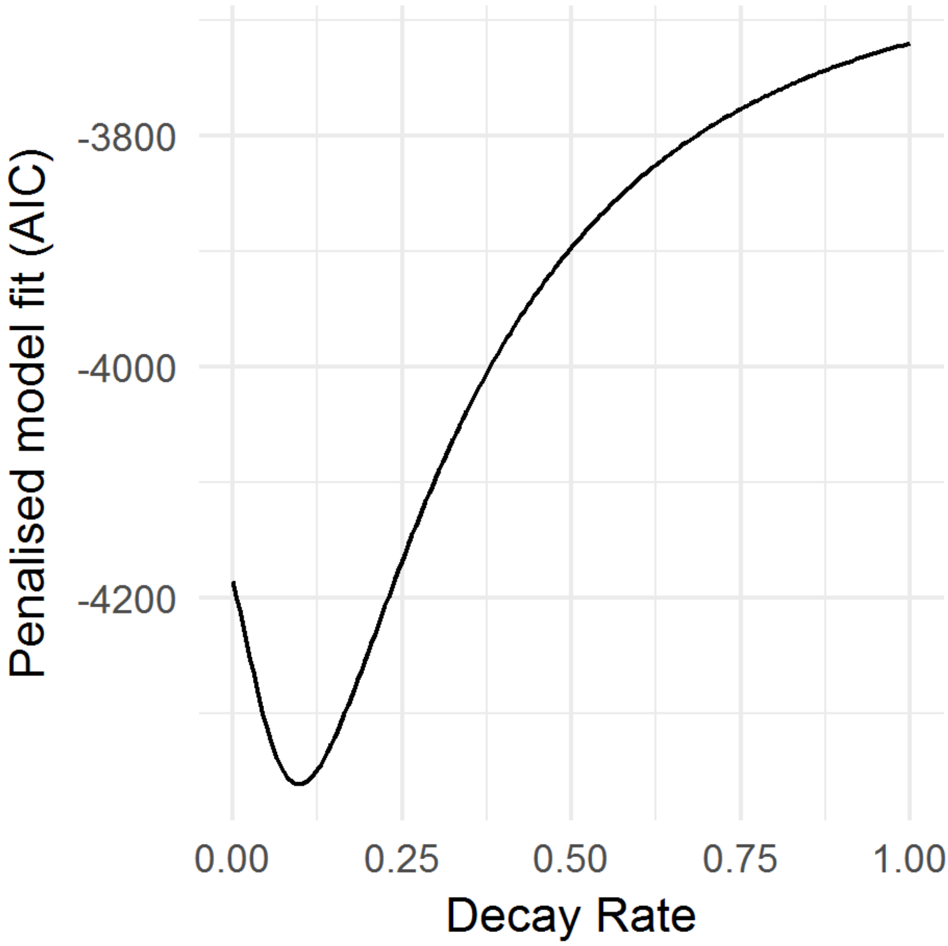

Figure 7: The relationship between decay parameter and model fit using AIC. (Lower AIC value = better)

Counterfactual estimation

Using the approach described in the methods section, the number of additional deaths attributed to the Troubles by the model can be estimated by applying mortality risks to population sizes under both the 'with-Troubles' and 'without-Troubles' scenarios. Figure 8 shows the estimated number of additional deaths at each age and year after 1972. These tend to be concentrated at the youngest adult ages, then reduce with age. This is further confirmed by extracting the coefficient associated with the Troubles for each age, as shown in Figure 9, which include the equivalent coefficients for females if using the same model specification.

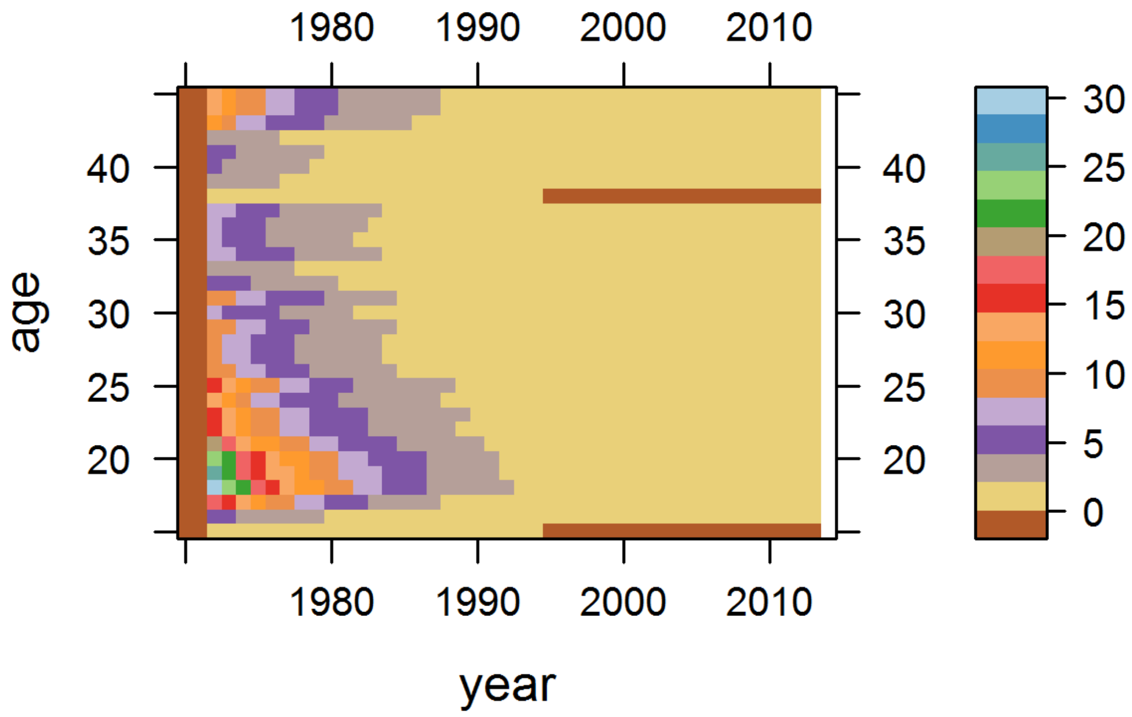

Figure 8: Model estimated 'excess deaths' due to the Troubles from 1970 onwards, in males in Northern Ireland aged 15-45 years. Colours indicate numbers of deaths by age and year; the legend is shown on the right.

For males the effect is positive at almost all ages, and is largest at age 18, then falls at most older ages; for females it tends to be negative, suggesting the model may be misspecified for females, and instead captures broader continual improvements in mortality risks over this time period. Table 1 shows the number of estimated additional male deaths by year and age group in five year intervals to the nearest whole number for each year from 1972 to 2013, with margins indicating the total number by year and age. This estimates nearly 2800 additional deaths by 2013, with over 1000 occurring in the first three years of the conflict from 1972 to 1975. Looking by age, over half of the estimated deaths (1470 out of 2776) are estimated to have occurred in boys and men aged between 15 and 25 years inclusive.

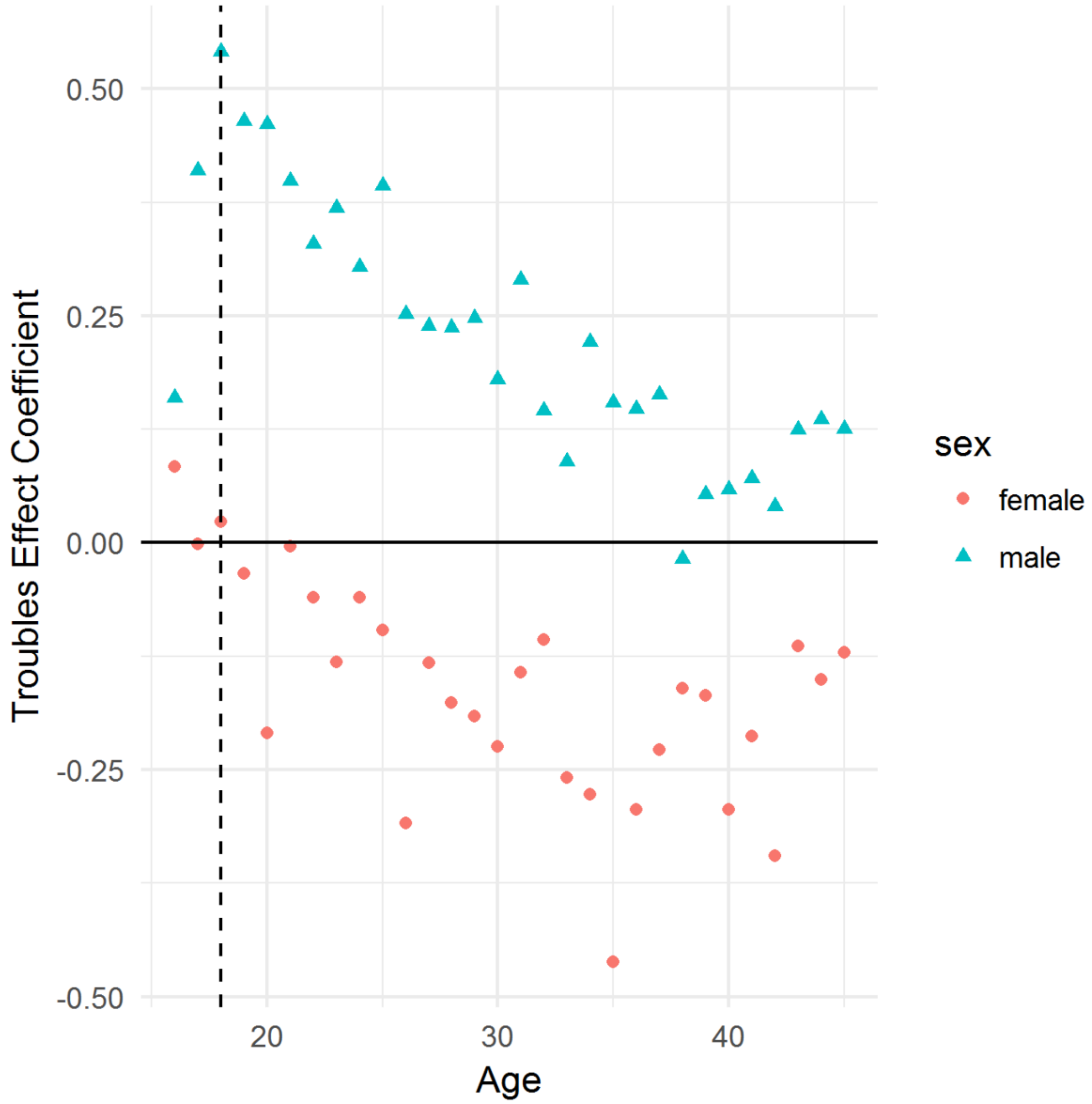

Figure 9: Coefficient of the 'Troubles parameter' by age in single years for males (blue triangle) and females (red circle).

	Age Group							
Year	[15,20]	(20,25]	(25,30]	(30,35]	(35,40]	(40,45]	**Total**	**Cumulative**
1972	101	78	43	32	22	46	322	322
1973	86	67	39	29	19	39	279	601
1974	73	58	34	26	17	34	243	844
1975	64	50	30	23	15	30	212	1056
1976	56	43	26	21	13	26	186	1242
1977	49	38	23	19	12	23	164	1407
1978	44	34	20	17	11	20	146	1552
1979	39	30	18	15	10	18	130	1682
1980	35	27	16	13	9	16	116	1798
1981	32	24	14	12	8	14	104	1902
1982	28	22	12	11	7	13	93	1995
1983	25	20	11	9	7	11	84	2079
1984	22	18	10	8	6	10	75	2154
1985	20	16	9	7	5	9	67	2221
1986	17	15	8	7	5	9	61	2282
1987	15	13	8	6	4	8	54	2336
1988	13	12	7	6	4	7	49	2385
1989	11	10	6	5	3	6	43	2428
1990	10	9	6	5	3	6	39	2466
1991	9	8	5	4	3	5	35	2501
1992	8	7	5	4	3	5	31	2532
1993	7	7	4	4	2	4	28	2560
1994	6	6	4	3	2	4	25	2585
1995	5	5	4	3	2	3	22	2607
1996	5	5	3	3	2	3	20	2627
1997	4	4	3	3	2	3	18	2645
1998	4	3	3	2	2	3	16	2661
1999	3	3	2	2	1	2	14	2675
2000	3	3	2	2	1	2	13	2688
2001	3	2	2	2	1	2	11	2700
2002	3	2	1	1	1	2	10	2710
2003	2	2	1	1	1	2	9	2719
2004	2	2	1	1	1	1	9	2728
2005	2	2	1	1	1	1	8	2736
2006	2	2	1	1	1	1	7	2743
2007	2	1	1	1	1	1	6	2749
2008	1	1	1	1	1	1	6	2755
2009	1	1	1	1	0	1	5	2760
2010	1	1	1	1	0	1	5	2765
2011	1	1	1	1	0	1	4	2769
2012	1	1	1	0	0	1	4	2773
2013	1	1	0	0	0	1	3	**2776**
Total	816	654	388	313	208	395	**2776**	

Table 1 Model estimates of numbers of Troubles-attributable deaths in males in Northern Ireland by year and age group

Discussion

Comparison of mortality estimates

(Smyth, 1998) estimated a total of 3598 deaths were attributed killings in the conflict between 1969 and 1998; this compares with 2661 estimated in our model between 1969 and 1998 in younger adult males in Northern Ireland only. Other total mortality estimates for the Troubles tend to be similar, with (McDowell, 2008) estimating slightly under 3700 deaths, and (Curran, 2001) estimating 3740 additional deaths between 1969 and 1999 (compared with our estimate of 2675 between 1972 and 1999). (Smyth, 1998) also found that a disproportionate share of deaths occurred in young adults, with a quarter occurring in people aged 18-23 years, and attributable deaths then falling at older ages. We found a qualitatively similar pattern of mortality burden by age, though with an even greater share in 18-23 age group, with 1053 deaths out of 2776, or 38% of all deaths, estimated.

Our model, based only on all-cause mortality data, estimates around three quarters of the deaths that actually occurred, suggesting that the key modelling assumption - an initiation event leading to the sudden onset of a conflict whose intensity only slowly decays over many years – captures something of the essence of what occurred in Northern Ireland.

There may be two reasons why our estimates are below death counts directly attributed to political violence, in addition to our use of a more restrictive demographic group. Firstly, we did not explicitly model to include the particularly high spike of deaths in 1973. Secondly, adult males experience an increase mortality once they reach adulthood, and young adult male mortality displacement effects may occurred in Northern Ireland after the Troubles began. For example rates of homicide risk and suicide risk tend to be inversely correlated, and that both disproportionately affect younger adult males. (Curran, 2001; Durkheim, 1951; Lester, 2002) It may be that the high rates of 'bonding capital' within Northern Irish communities, though responsible for the maintenance of sectarian conflict, were also protective against some other forms of mortality risk, such as alcohol and drug-related deaths, that otherwise would have claimed more young adult males. (Leonard, 2004) In the counterfactual scenario, therefore, it may well have been that some of those who did not die of sectarian violence instead died of some of these other causes, and so the net deaths 'caused' by the conflict may be less than the number of people who died of conflict-related violence.

Methodological considerations and implications

This research originated through the use of Lexis surface visualisation to compare mortality trends in Scotland against neighbouring populations. (Minton et al., 2017) Scotland was compared firstly against the rest of the UK, then against England and Wales, and Northern Ireland separately. In this last comparison a distinct visual 'signal' in Northern Irish male mortality was identified after 1972 mortality risks in in that Scottish young adult male mortality rates, which generally lag Northern Ireland's, suddenly looked better in comparison, whereas female rates did not. Northern Irish young adult male mortality was worse during the peak of the Troubles worse than in Eastern Europe. The incidental and accidental origins of this paper therefore highlight the value to us of the data visualisation approaches employed, and of what Robert K Merton called 'theories of the middle range', of allowing social hypotheses to 'emerge upwards', inductively or abductively from data exploration, rather than simply being 'applied downwards', beginning in canonical social texts, then operationalised and empirically tested in a hypothetico-deductive fashion. (Menand, 2009; Merton, 1968)

The specific model specification, including first an impulse component then an exponential decay, can be used to model particular types of mortality pattern disruption, likely attributable to violence or more general social disorder, even when only relatively limited all-cause mortality data are available, and specific death codes, such as ICD-10 codes, are not recorded consistently. This situation is likely to be the case both for less affluent nations in more recent years, as well as for historic demographic data from more affluent data. One specific benefit of the modelling approach used here is in allowing conflict-attributable mortality to be compared in terms of both initial intensity (the height of the initiation in the first year) and also duration in terms of decay rates and so conflict half-life.

The model appears characteristic of a population that was in some senses ‘febrile’ or ‘fissile’ in its response to exogenous social, political and economic events and processes, and is to some extent consistent with previous attempts to model processes of violence as complex systems involving either systems of nonlinear equations or agent-based models. (Wright, 2006) A paper describing an agent-based model of processes and dynamics of civil war emphasises the punctuated equilibria – sudden increases in violence punctuating longer periods of relative calm – can be expected in such complex systems, and that it is important to consider the ways that agents involved in war adapt over time in their attitudes and behaviour.(Findley, 2008) Though it took a number of years, possibly three years, for the series of events which began in the late 1960s to lead to the initiation of conflict, this effect of this conflict was then sustained endogenously over many decades. This appears to represent the essence of cycles of violence driven by tit-for-tat processes of recrimination and revenge. For both sides, justice meant responding to violence with violence, a process of call and response in deadly conflict that, like an echo in a cave, only diminished slowly in intensity over time. Once this wave of conflict was initiated, it may have been that there was little that external agents could have done to either exacerbate or hasten the process of decline in violence.

Implications of the initiation-decay model to conflict in Northern Ireland

If, once initiated, the conflict was largely endogenously sustained, this has important implications for how the various peace initiatives and processes which were attempted after 1972 should be interpreted in terms of their effectiveness. Up to seven prior attempts at bringing peace to Northern Ireland were made between 1969 and the Belfast Agreement of 1998, including the Sunningdale Agreement of 1973. It has been argued that what made the Belfast successful was the presence of key individuals acting effectively as ‘brokers’ in the complex social networks which had to be negotiated at the time.(Goddard, 2012) However, if the underlying dynamics of the model are accurate, then such factors may be greatly overstated. If the half-life of the conflict was 6.76 years and began in 1972, it follows that by 1994 the intensity of the conflict had diminished to around one-tenth of its initial level. (i.e. $(1-k)^{(1994-1972)} = 0.105$). Similarly, by the time of the Good Friday Agreement in 1998 the underlying conflict intensity had diminished to around 7% of its initial value (i.e. $(1-k)^{(1998-1972)} = 0.069$). Note that these intensity values apply to $\log_{10}$ mortality risks, so the actual level of decline of conflict intensity on deaths by the mid to late 1990s will have been even greater.

The power sharing arrangement following the Good Friday Agreement (GFA) has been described as an example of ‘consociationalism’, a system of government in which coalition by both Republicans and Loyalists is mandated.(Anderson, 2008) The consociational arrangement following the GFA has led to little change in the ethno-sectarian identity focus of any of the main parties within Northern Ireland. Indeed, the political success of Sinn Fein at the expense of the more moderate Social Democratic and Labour Party (SDLP) in capturing the Irish Nationalist voting block after the GFA suggests sectarian identity may have come to matter more, not less, to voting intentions following the GFA.(McGlynn, Tonge, & McAuley, 2014) Cross-ethnic political parties have seen only limited success after the GFA compared with sectarian political parties, and this lack of success has been attributed to the consociationalist institutions established in the wake of the GFA to accommodate (rather than attempt to blend) rival identities.(Murtagh, 2015) Questions have therefore been raised about whether the GFA represents or helps to bring about conflict *resolution*, or is simply conflict *management*, or more pessimistically, conflict deferment.(Anderson, 2008)

Whereas ethno-national conflict since the establishment of Northern Ireland in 1921 sharpened the border with the Republic of Ireland, the European Single Market made it more permeable.(Anderson & O’Dowd, 1999) EU Peace Programmes for Northern Ireland and the Border Counties began in 1995 with the Special Support Programme for Peace and Reconciliation (Peace I) which provided €500 million in structural funds to the region, supplemented with an additional €167 from government;

followed by the Programme for Peace and Reconciliation (Peace II), which provided €531million via the EU and an additional €304 from national governments between 2000 and 2004.(Buchanan, 2008) The third phase of the EU programme for Peace and Reconciliation in Northern Ireland took place over the years 2007 to 2013. (Karari, Byrne, Skarlato, Ahmed, & Hyde, 2013) Whereas the GFA focused on building peace by addressing the leaders of political factions, EU-led initiatives focused on economic investment and to greater community engagement as a means of building more lasting stability in Northern Ireland and the Irish border. The UK's departure places the future of further initiatives in doubt, though the Irish border remains a key priority for EU-UK Brexit negotiations.

At the time of writing (13 June 2017), in the days following the 2017 General Election, particular attention has been paid in the UK mainland to the socially conservative views of the DUP on issues including abortion, homosexuality, and gay marriage. Gay marriage is now legal in the Republic of Ireland, and Northern Ireland remains the only part of the UK in which abortion is illegal, suggesting that Northern Ireland possesses greater religious social conservatism than either 'Catholic Ireland' or 'Protestant England'. Many aspects of this social conservatism, for those in Northern Ireland to possess social attitudes considered 'regressive' in neighbouring countries, may itself result from lingering sectarian tension, and a phenomenon in social psychology known as the 'secondary transfer effect' (STE), which posits that once two antagonistic groups develop more positive attitudes to one another, attitudes towards additional outgroups – such as ethnic minorities, homosexuals, and teenage parents – also tend to become more positive and accepting. (Tausch et al., 2010) Without mutual acceptance by Unionists' and Nationalists' of each group's primary outgroup (Nationalists and Unionists respectively), acceptance and tolerance towards other outgroups may continue to lag behind those in neighbouring countries. (Ashe, 2009; Schmid, Hewstone, & Tausch, 2014) A barometer for latent sectarianism within Northern Ireland, and thus the degree to which UK-led political actions relating to Brexit could initiate a new wave of decades-long conflict, may therefore be attitudes and behaviours directed towards people who are neither Unionist nor Catholic, neither Loyalist nor Nationalist, but simply different.

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