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Area-level mortality and morbidity predict 'abortion proportion' in England and Wales

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ABSTRACT

Life history theory predicts that where mortality/morbidity is high, earlier reproduction will be favoured. A key component of reproductive decision-making in high income contexts is induced abortion. Accordingly, relationships between mortality/morbidity and 'abortion proportion' (proportion of conceptions ending in abortion) are explored at small-area ('ward') level in England and Wales. It is predicted that where mortality/morbidity is high, there will be a lower 'abortion proportion' in younger women (<25 years), adjusting for education, unemployment, income, housing tenure and population density. Results show that this prediction is supported: wards with both shorter life expectancy and a higher proportion of people with a limiting long-standing illness have lower abortion proportions in under 25 s. In older age bands, in contrast, elevated mortality and morbidity are mostly associated with a higher 'abortion proportion'. Further, morbidity appears to have a larger effect than mortality on 'abortion proportion' in the under-25 age band, perhaps because a) morbidity is be more salient than mortality in high-income contexts, and/or b) young women are influenced by health of potential female alloparents when scheduling fertility.

1. Introduction

1.1. Life history theory

Life history theory posits that over the life course organisms face tradeoffs in allocating energy between competing functions such as growing, learning, mating, reproducing and self-care (Roff, 1992; Stearns, 1992). The optimal balance of these trade-offs to maximise reproductive fitness will depend on the local ecology (Schaffer, 1983). One characteristic which varies between ecologies is extrinsic mortality (and morbidity) risk, defined as the risk of death that is not conditional on an organism's reproductive behaviour (Stearns, 1992, p. 182). An organism cannot escape extrinsic mortality by behaving differently, as it is the "age-specific risk of death that is equally shared by all members of a population" (Quinlan, 2010, p. 125). Such risks are therefore important in setting the time horizon of energetic allocation, which will change the costs and benefits of energetic allocation to each respective function and the prioritisation of each. Mortality and morbidity curtail ability to conceive, bear and care for offspring (Geronimus, Bound, & Waidmann, 1999).

Indicators of a high mortality environment may be associated with 'faster' life histories, typified by accelerated reproductive development and earlier age at first reproduction, so that reproduction is temporally prioritised over growth and learning, in order to ensure it takes place while still relatively young and healthy. 'Slower' life histories occur in low mortality/less risky environments (Charnov, 1991), where individuals can afford to substantially invest in their embodied capital before reproducing.

Life histories can diverge between species (Promislow & Harvey, 1990) and within species (Reznick, Bryga, & Endler, 1990); and are not necessarily governed by conscious decision-making (Engqvist & Sauer, 2002; Javois & Tammaru, 2004). Across 22 small-scale human societies, high mortality rates were associated with earlier age at menarche and earlier reproduction (Walker et al., 2006). Such adaptations can happen over evolutionary time (Migliano, Vinicius, & Lahr, 2007); or within a lifespan, environmental cues can influence an organism's phenotype via evolved adaptive mechanisms. Within human lifespans, such effects may occur via physiological and psychological mechanisms (Del Giudice & Belsky, 2011; Nettle, 2011). As long as individuals are receiving enough calories to be fertile, mortality is therefore expected to influence reproductive scheduling (Belsky, Schlomer, & Ellis, 2012).

1.2. Health inequalities

This theoretical framework has been used to help explain socioeconomic differences in reproductive behaviour in high income contexts in our own species (Nettle, 2010). Poorer people when compared to richer people are more exposed to extrinsic morbidity and mortality hazards such as accidental death, homicide, air pollution and heart

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disease in their localities, adjusting for individual-level factors (Bolte, Tamburlini, & Kohlhuber, 2010; Cubbin, LeClere, & Smith, 2000; Smith, Hart, Watt, Hole, & Hawthorne, 1998). Those in the most deprived neighbourhoods may face a 2.5-fold increase in mortality risk when compared to those from the least deprived areas (CSDH, 2008). Morbidity can have even sharper socioeconomic differentials (Bajekal, 2005). It has now been consistently shown that within developed societies poorer people have children earlier (Geronimus et al., 1999; Imamura et al., 2007; Joshi, Hawkes, & Ward, 2004; Nettle & Cockerill, 2010). This empirical finding stimulated the 'weathering hypothesis' (Burton, 1990; Geronimus, 1992, 1996a, 1996b), which suggests that those with higher mortality and morbidity risk may schedule fertility earlier to mitigate reproductive costs, which increase more rapidly with age in those who experience relatively high burdens of morbidity. Nettle and colleagues have developed an explicitly evolutionary version of this hypothesis, whereby such behaviour makes sense in terms of maximising fitness (Nettle, 2010, 2011; Nettle & Cockerill, 2010). Further increasing the incentives to earlier reproduction is the suggestion that there can be educational and career benefits to delaying childbearing, but those at greater risk of mortality/morbidity may be less able to make these investments, despite potential long-term benefits to children (Bulled & Sosis, 2010; Geronimus, 1996b; Kaplan, Hill, Lancaster, & Hurtado, 2000; Krupp, 2012; Low, Hazel, Parker, & Welch, 2008; Nettle, 2011; Nguyen et al., 2012). Poorer families appear to disperse less for economic opportunities (Murphy, 2008; Sear & Dickins, 2010), which means that childcare is more likely to be undertaken by family (Kramer & Lancaster, 2010), so that early reproduction is optimal before one's relatives (mother, for example) see early functional limitation and mortality (Bajekal, 2005; Geronimus et al., 1999).

1.3. Rationale for investigating abortion

Research so far on links between mortality risk or socioeconomic status and the timing of childbearing have focused largely on births or conceptions. Conceptions do not always lead to births, however. A key component of reproductive decision-making in high income contexts is induced abortion. In most such contexts, safe medical abortion is relatively easily accessible and widely used by women as a means of managing their reproductive lives. Its incidence in developed countries where it is legal ranged in 2008 from 30 per 1000 women aged 15–44 in Estonia to Switzerland (seven per 1000). In terms of the proportion of pregnancies that end in induced abortion, the lowest in 2008 was in Israel (10%) and the highest was again in Estonia (30%) (Sedgh, Singh, Henshaw, & Bankole, 2011). Indeed, in some countries there has long been a tendency to use abortion as a contraceptive (e.g. in the former Soviet states) (Agadjanian, 2002); while in others, even where abortion is illegal, unsafe informal procedures or alternatives like menstrual regulation or abortifacients are used (Sedgh et al., 2011; Vlassoff, Hossain, Maddow-Zimet, Singh, & Bhuiyan, 2012). Therefore it can be seen as an important means of managing reproduction.

Hrdy (1979) argues that termination of investment in an offspring (e.g. infanticide) is an adaptive reproductive strategy in animals including primates in circumstances where there can be increased maternal survival or reproductive success of either parent "by elimination of an ill-timed, handicapped or supernumerary infant"(p.13). She also points out that in comparison to other primates humans are unusual in that they quite frequently terminate investment in infants, something which she attributes to the high costs of raising human children (Hrdy, 2009). This means there may well be an associated evolved psychology which enables facultative variation in the decision as to whether to continue investment in an offspring. Ancestrally, induced abortion was riskier for the mother than now, and infanticide was safer. In developed societies the situation is reversed, especially if abortion takes place in the early stages of pregnancy. The gain for the parent can depend on their personal attributes e.g. age and likely opportunity cost of bearing and rearing offspring currently, which may in itself vary depending on local resources and risks.

1.4. Abortion across the reproductive lifespan

Theoretically speaking, we would expect abortion rates to vary with age. Abortion rates show a J-shaped curve with age, at least in high income contexts – younger women tend to be the most likely to abort, abortion rates are lowest among women in their thirties then start to increase towards the end of the reproductive period (Lycett & Dunbar, 1999). This likely reflects both the changing costs and benefits of abortion with age – younger women have more opportunity to conceive again – and also the different reasons for abortion – younger women may be using it to manage the timing of their reproduction (e.g. to allow time for education or career-building; finding a secure partnership) (Lee, Clements, Ingham, & Stone, 2004; Lycett & Dunbar, 1999) while older women may be using it to manage family size or to abort less viable foetuses (as the risks of chromosomal abnormalities increase with maternal age). We also expect the relationship between abortion and morbidity/mortality to vary by age. Environments with high mortality/morbidity may be ones where norms encouraging investment in higher education do not develop because the long-term benefits of education are less clear, as waiting to reproduce may be a risky strategy. If this is the case then there is less need for fertility postponement and therefore we would expect to see lower abortion levels in younger age groups in areas with higher morbidity/mortality. Indeed there is an inverse relationship between education and abortion among young women (Diamond, Clements, Stone, & Ingham, 1999; Lee et al., 2004; Lo, Kaul, Kaul, Cooling, & Calvert, 1994; Wood, 1996).

1.5. Deprivation and abortion

There has been some previous research on how deprivation influences abortion. In the UK, more deprived individuals and communities have both lower levels of abortion (controlling for conceptions), and show less acceptance of it (Lee et al., 2004). Research on links between abortion and deprivation mostly comes from policymakers' interest in teenage pregnancy. These studies tend to measure deprivation in different ways, owing to its multidimensional nature. Much of the research also uses area-level data, given the sensitive nature of abortion and concerns about the risk of revealing individual identities. Quantitative area-level research often uses 'abortion proportion' as its outcome variable, i.e. the proportion of conceptions ending in abortion. At area level it is often the case that deprived areas with a high teenage conception rate also have a low abortion proportion (Bradshaw, Finch, & Miles, 2005; Garlick, Ineichen, & Hudson, 1993). There are descriptive and correlational studies (Garlick et al., 1993; Griffiths & Kirby, 2000; Smith, 1993; Uren, Sheers, & Dattani, 2007; Wilkinson et al., 2006; Wilson, Brown, & Richards, 1992; Wood, 1996) and multivariate research (Bradshaw et al., 2005; Conrad, 2012; Diamond et al., 1999; Lee et al., 2004; McLeod, 2001) showing the inverse relationship between deprivation and abortion. There is also some questionnaire and survey research confirming the same pattern at individual level (Lo et al., 1994; Smith & Roberts, 2009; Wellings, Wadsworth, Johnson, Field, & Macdowell, 1999). The studies just cited also show that repeatedly, deprivation is a far stronger factor in abortion proportion than the proximity and availability of contraception and abortion services, or the balance of state versus private provision; although in phase two of one study both the percentage of female GPs in local authorities and an index of opening hours of family planning clinics were also significant in final models (Lee et al., 2004). Similar patterns may hold elsewhere: one study in Barcelona shows that although with unintended pregnancy, women of lower socioeconomic position are more likely to choose abortion, this is not the case when they are young (Font-Ribera, Perez, & Borrell, 2008). And in the US and Sweden, deprived teens are less likely to have abortions than richer ones (Harding, 2003; Olausson, Haglund, Weitoft, & Cnattingius, 2001). However, it remains to be seen whether morbidity and morbidity are contributors.

1.6. Morbidity, mortality and abortion

If deprivation is associated with higher mortality and morbidity risk then the research described above suggests that mortality and morbidity will be linked to abortion proportion, but little research has directly tested this hypothesis. Even the most sophisticated studies (Diamond et al., 1999; Lee et al., 2004) have not used health measures among their deprivation indices. Although Wilson et al. (1992) find area-level associations between abortion proportion and Standardised Mortality Ratio, the latter was their only deprivation measure. The only multivariate research measuring health (Bradshaw et al., 2005) finds 'health deprivation and disability' retaining significance where other deprivation measures like income, housing, child poverty and education, skills and training do not, but the study measures health at local-authority area level, an area too large and heterogeneous to really tell us much. Although Krupp (2012) found in Canada that life expectancy positively predicted abortion rate, controlling at provincial level for median household income and at health region level for annual personal income, the geographical areas used are large and heterogeneous; and more varied socioeconomic controls would be ideal, as well as examining patterns in different age bands. If, as the evolutionary literature assumes, local cues to mortality are acting as inputs to evolved psychological mechanisms for reproductive motivation (Nettle, 2011; Wilson & Daly, 1997), then it is important to use small geographical areas to assess local correlations. The current study is able to do this, explained more in the Method section.

1.7. Predictions

The main research herein makes predictions regarding relationships between abortion and health in the under-25 age band only, as it is here where abortion is most likely used as a means of fertility postponement due to educational/career opportunities. For older age groups abortion relates less to fertility timing (Bankole, Singh, & Haas, 1998; Finer, Frohwirth, Dauphinee, Singh, & Moore, 2005; Lycett & Dunbar, 1999; Sihvo, Bajos, & Ducot, 2003; Tullberg & Lummaa, 2001). Due to the lack of parity information in the abortion proportion measure, we cannot tell whether abortion in the older age bands is being used for fertility postponement or family size limitation, and this is likely to vary between socioeconomic groups within a given age band due to differential fertility commencement ages. Adjusted relationships between abortion and health are explored in three older age bands (25–29, 30–34 and 35 and over). We test the following hypotheses:

Hypothesis One. Area-level mortality will be negatively related to area abortion proportion in the under-25 age band, all else equal. This means that life expectancy measures will see a positive relationship with abortion proportion, adjusting for education, income, unemployment, population density and housing tenure.

Hypothesis Two. Area-level morbidity will be negatively related to area abortion proportion in the under-25 age band, all else equal. This means that the measure of morbidity prevalence (i.e. age-standardised long-term limiting illness) is predicted to have a negative relationship with abortion proportion, adjusting for education, income, unemployment, population density and housing tenure.

2. Material and Methods

2.1. Spatial units

The geographical level used for our data is the ward. These wards originated as the spatial units used to elect local government councillors within the UK. Since the original electoral wards tended to undergo frequent boundary changes, different types of ward have been created for statistical use. More detail about the merging of data from different ward types necessary for this study is available in the Appendix. In summary, most of the data used here are from the 2001 national Census, with other data centred approximately on this time period. All the data are from England and Wales, since data are collated and summarised differently in other parts of the UK. The final sample size was 8752 wards. For full details of the construction of variables, ward types, and sources of data, see Appendix A. Census Area Statistics (CAS) wards for 2001 had a mean population of 5,968 (min. = 66; max. = 35,748). This means that they have a far smaller population size than the kinds of geographical entities largely used in previous abortion research. This should reduce any problems involved in making area-level assumptions about 'local cues' and somewhat mitigate the ecological fallacy, the false assumption that the same relationships seen at aggregate level necessarily hold at individual level (Piantadosi, Byar, & Green, 1988). As Lancaster, Green, and Lane (2006) note, in the absence of individual-level information, ward-level data are more useful than those covering larger areas as between-area variability is preserved. Individual-level abortion data were unavailable from the Office for National Statistics (ONS) due to their sensitive and confidential nature, but the acquired ward-level data are at a greater level of resolution than the routinely available local authority-level figures. Additionally, because conception and abortion are both relatively rare events, for reasons of statistical reliability data were aggregated from 1999 to 2003.

2.2. Key measures

Although the resulting measure, 'abortion proportion' (AP) cannot show base conception rates, it may be seen as an aggregation of individual-level effects and/or ecological norms which can then be assessed for their association with area-level mortality, while adjusting for multiple socioeconomic factors. In using morbidity as an independent variable we can also examine whether any putative evolved psychological mechanisms might also be sensitive to cues to chronic ill-health. Abortion proportion is calculated jointly by the Department of Health (DoH) and the ONS. The DoH receive notifications of abortion from both private and National Health Service facilities (i.e. those defined as legal under the Abortion Act 1967); while maternity data (number of pregnant women who give birth, including one or more live or still births) comes from the ONS, who process birth registrations. The number of conceptions is thus inferred, and does not include miscarriages or illegal abortions.

Mortality was measured as life expectancy (life expectancy: defined as the average number of years a newborn baby would survive if he or she experienced the ward's age-specific mortality rates for that time period throughout his or her life); and for morbidity it was the age-standardised prevalence of limiting long-term illness (LLTI) (where 'limiting' is defined as 'limiting daily activities'). The Life Expectancy measure was chosen as a general assay of mortality, and is used for comparing wards as it is an age-standardised measure (i.e. not confounded by potential differences in age structure between wards); the available LLTI prevalence measure was then also age-standardised by the first author in order to avoid the same problem of confounding. Limiting Long-Term Illness is also a pertinent measure for operationalising the kind of morbidity thought by Geronimus (1992, 1996b) Geronimus et al. (1999) to interfere with reproduction and childrearing.

The morbidity measure was constructed only for individuals living in households, and excluding those living in 'communal establishments' e.g. old-age care homes, etc. These populations are not seen out and about in the local area, so they are unlikely to contribute to 'cues' of morbidity, an assumption which underpins the theoretical background of this work. Ward-level life expectancy estimates were calculated including these individuals, so our analyses control for a ward-level indicator of the proportion of the ward population aged 65 and over

Table 1
Summary statistics and frequencies for variables used in analysis.

Variable	Available n; mean; standard deviation; range; percentage frequencies				
Independent variables					
	N	Mean	SD	Min.	Max.
Mortality – Life Expectancy (life expectancy) in years	8752	78.9	2.6	65.4	93.4
Morbidity – proportion with age-standardised long-term limiting illness prevalence (LLTI)	8752	.17	.04	.08	.37
Dependent variables					
Abortion proportion age bands:	N	Mean	SD	Min.	Max.
Under-25	8747	.36	.14	0	1
25–29	8750	.15	.08	0	.6
30–34	8752	.12	.06	0	.44
35 and over	8736	.21	.08	0	.71
NB: A handful of wards have missing 'abortion proportion' data as where there are very small raw numbers they are suppressed by the Office for National Statistics for confidentiality reasons.					
Covariates – Continuous variables					
	N	Mean	SD	Min.	Max.
Education - proportion of people aged 16 to 74 with level 4 and 5 qualifications	8752	.20	.09	.03	.66
Unemployment - Proportion of people aged 18 to 64 claiming Jobseekers' Allowance	8752	.21	.02	0	.14
Income - Average weekly household net income estimate equivalised after housing costs (pounds)	8752	£350.17	£83.52	£170	£1000
Housing tenure - Proportion owner-occupied:	8752	.74	.14	.12	.99
Housing tenure - Proportion social rented housing:	8752	.15	.12	0	.83
Housing tenure - Proportion privately rented housing:	8752	.09	.07	0	.69
Housing tenure - Proportion rent-free:	8752	.02	.01	0	.33
Covariates – Categorical variables					
Population density - Urban/Rural	Total N			8752	
	Urban > 10 k population			N = 5636 (64.40%)	
	Town and fringe			N = 1327 (15.16%)	
	Villages hamlets & isolated dwellings			N = 1789 (20.44%)	
Proportion of persons living in Medical and Care establishments (quintiles)	Total N			8752	
From 0 (none of population in these establishments) to 5 (many of population in these establishments)	0 – none			N = 2893 (33.06%)	
NB: used only in models featuring Life Expectancy as independent variable	1			N = 1006 (11.49%)	
	2			N = 1889 (21.58%)	
	3			N = 1183 (13.52%)	
	4			N = 855 (9.77%)	
	5 - many			N = 926 (10.58%)	

resident in medical & care establishments in 2001 (i.e. nursing homes, residential care homes, hospices and hospitals).

2.3. Analysis

Initial relationships between mortality (life expectancy) or morbidity (LTLI) were tested using regression analysis. As the dependent variable (AP) took the form of a proportion, a generalised linear model was used with a logit link function to model the data with fractional logistic regression (Papke & Wooldridge, 1996). All models were run separately for the following age bands: <25 years, 25–29, 30–34 and 35 and over.

2.4. Control variables

Controls were then added to adjust for separate aspects of 'deprivation', which in aggregate predicts abortion proportion in young women, as seen in previous research. From previous multivariate work some disaggregated aspects of deprivation which have seen significant relationships with abortion proportion include general area prosperity (positive) (Griffiths & Kirby, 2000; Wood, 1996); proportion of students (positive) (Diamond et al., 1999); unemployment (both positive and negative)(Lee et al., 2004; Wilkinson et al., 2006); percentage of 11–15-year-olds dependent on parents claiming Family Credit, a historic UK state benefit for those on low pay (negative) (Lee et al., 2004); and access to services (negative) (Bradshaw et al., 2005), although these relationships are not consistent across studies nor always available at ward level. Therefore for the current study, controls were picked from available ward-level data from around the 2001 time period which were both standard indicators of deprivation/prosperity and which had some relationship with both mortality/morbidity and abortion proportion, not difficult due to the multidimensional nature of deprivation where different aspects are inter-related. Although initially it was intended to include covariates measuring the proportion of the population of different ethnicities and religions/no religion, there was very small variance in most of these variables as most wards had overwhelmingly White British populations identifying as Christian. Accordingly these variables were excluded from the analysis. The final controls used were the following, with more detail under 'Covariates' in Appendix B.

- Education: proportion of people aged 16 to 74 with level 4 and 5 qualifications, which were the highest level, including first degree, higher degree, and a number of other professional/technical qualifications
- Unemployment: proportion of people aged 18 to 64 claiming jobseekers' allowance
- Income: average weekly household net income equivalised after housing costs (pounds sterling)
- Housing tenure: proportion of people in each type of housing tenure: owner-occupied; social rented housing; privately rented housing; rent-free
- Population density (dummy variable): urban (>10 K population); town and fringe; villages, hamlets and isolated dwellings

A correlation matrix showing relationships between independent variables co-occurring in the same model unsurprisingly indicated high collinearity (exceeding .8) between proportion of population in owned housing and the proportion of people in social rented housing

Table 2
Unadjusted regression models show that life expectancy positively predicts abortion proportion in under-25 s; and negatively predicts abortion proportion in older age bands.

	Under-25 abortion proportion			25–29 abortion proportion			30–34 abortion proportion			35 and over abortion proportion		
	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value
Life expectancy	0.088	0.003	<0.001	−0.048	0.003	<0.001	−0.094	0.002	<0.001	−0.053	0.002	<0.001
Proportion of population in medical & care establishments	0.049	0.004	<0.001	−0.018	0.004	<0.001	−0.052	0.004	<0.001	−0.033	0.003	<0.001
Constant	−7.626	0.218	<0.001	2.076	0.227	<0.001	5.538	0.191	<0.001	2.897	0.177	<0.001

NB: proportion of population in medical & care establishments is included in unadjusted models as a high score can shorten ward life expectancy; and it is not a covariate associated with ward deprivation, unlike control variables used in adjusted models.

(−.87). Therefore the latter variable was omitted from analyses. As the goal of the analysis was not to produce a predictive model with the fewest number of variables, but to adjust for baseline differences between wards to avoid confounding, controls were entered in the model simultaneously (Katz, 2011) in order to test whether associations between mortality/morbidity and abortion proportion remained after these adjustments.

3. Results and Discussion

3.1. Summary Statistics

Summary statistics for variables are seen in Table 1.

3.2. Unadjusted and adjusted relationships between mortality and 'abortion proportion'

As indicated in Section 2.3, we used fractional logit models due to the dependent variable being a proportion; and models are separate for age bands <25 years, 25–29, 30–34 and 35 and over.

Results for the unadjusted and adjusted models indicating relationships between mortality and abortion proportion in all age bands are shown in Tables 2 and 3 respectively.

The unadjusted and adjusted models showing relationships between morbidity and abortion proportion in all age bands are shown in Tables 4 and 5 respectively. It is important to note that because of the different ways that mortality (Life Expectancy) and morbidity (Long-Term Limiting Illness prevalence) are measured, the positive relationship between mortality and abortion proportion and morbidity and abortion proportion are displayed with a positive and negative coefficient respectively, despite amounting substantively to the same thing (i.e. wards with higher mortality have a lower life expectancy; wards with higher morbidity have a higher proportion with a long-term limiting illness).

3.3. Support for hypotheses

Supporting our predictions, elevated mortality and morbidity were both associated with lower under-25 abortion proportion, when adjusting for education, income, population density, unemployment, and housing tenure. Elevated mortality and morbidity were however associated with higher abortion proportion for age bands 25–29 and 30–34, all else equal. Therefore we find that in disaggregating mortality and morbidity from other socioeconomic measures, there remains an association with abortion proportion, following predictions from life history theory and the 'weathering hypothesis'. Nonetheless, while 35

Table 3
Adjusted regression models show that life expectancy positively predicts abortion proportion in under-25 s; and negatively predicts abortion proportion in older age bands.

	Under 25 abortion proportion			25–29 abortion proportion			30–34 abortion proportion			35 and over abortion proportion		
	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value
Life Expectancy	0.008	0.003	0.013	−0.014	0.003	<0.001	−0.016	0.003	<0.001	−0.009	0.003	0.006
Proportion of population in medical & care establishments	−0.004	0.004	0.223	−0.008	0.004	0.043	−0.016	0.004	<0.001	−0.012	0.004	0.001
Deprivation-related control variables												
Proportion of pop 16–74 with level 4/5 qualifications	3.318	0.099	<0.001	1.596	0.095	<0.001	−0.462	0.091	<0.001	−1.027	0.087	<0.001
Household weekly income	0.001	0.000	<0.001	0.001	0.000	<0.001	0.000	0.000	<0.001	0.000	0.000	<0.001
Urban/Rural (ref: population > 10 K)												
'Town and Fringe' wards	−0.113	0.014	<0.001	−0.172	0.017	<0.001	−0.156	0.017	<0.001	−0.094	0.016	<0.001
'Villages hamlets and isolated dwellings' wards	−0.014	0.018	0.432	−0.250	0.020	<0.001	−0.290	0.019	<0.001	−0.206	0.018	<0.001
Proportion of pop 18–64 claiming jobseekers' allowance	0.069	0.527	0.896	4.308	0.505	<0.001	3.731	0.495	<0.001	1.675	0.526	0.001
Housing tenure:												
Proportion of population renting private housing	0.255	0.124	0.041	0.594	0.100	<0.001	0.626	0.094	<0.001	0.235	0.098	0.016
Proportion of population living rent-free	0.172	0.562	0.760	−1.728	0.505	0.001	−1.867	0.489	<0.001	−1.790	0.507	<0.001
Proportion of population living in owned housing	0.536	0.059	<0.001	−1.401	0.055	<0.001	−1.323	0.056	<0.001	−0.550	0.057	<0.001
Constant	−2.577	0.258	<0.001	−0.392	0.259	0.130	0.183	0.249	0.463	−0.087	0.259	0.736

Table 4
Unadjusted regression models show that age-standardised long-term limiting illness negatively predicts abortion proportion in under-25 s; and positively predicts abortion proportion in older age bands.

	Under-25 abortion proportion			25–29 abortion proportion			30–34 abortion proportion			35 and over abortion proportion		
	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value
Age-standardised long-term limiting illness prevalence	−6.949	0.131	<0.001	1.901	0.135	<0.001	5.205	0.122	<0.001	3.088	0.117	<0.001
Constant	0.620	0.024	<0.001	−2.080	0.025	<0.001	−2.894	0.022	<0.001	−1.859	0.021	<0.001

and over abortion proportion is also positively predicted by elevated mortality, there exists no such significant relationship with elevated morbidity once controls are added.

3.4. Relationship of control variables to 'abortion proportion'

Tables 3 and 5 show that once different components of deprivation are measured separately, but entered they have somewhat different relationships to abortion proportion. Education shows a similar 'age flip' to mortality and morbidity, in that the relationship between it and abortion proportion is positive in age bands <25 and 25–29; and then becomes negative for age bands 30–34 and 35 and over. This switch therefore happens at an older age than for the relationship between mortality/morbidity and abortion proportion, where the change in direction of effect is between the <25 and 25–29 age bands. Unemployment is consistently positively related to abortion proportion across age bands (notwithstanding the non-significant relationship for under-25 s in Table 3), while income is the same but with a tiny effect size. Population density results show that, all else equal, both 'Town and Fringe' and 'Villages, Hamlets and Isolated Dwellings' wards have lower abortion proportion across all age bands than wards where the population is greater than 10,000 (although for both tables the result is non-significant for under-25 s), and this effect seems to be stronger in the most rural wards. Across age bands the abortion proportion is positively associated with the proportion of private rented housing, all else equal, while a higher proportion of owned housing is associated with a higher under-25 abortion proportion, but thereafter a lower one. Thus the relationship between deprivation and abortion proportion is complex due to deprivation's multidimensionality, and differing opportunities and constraints relating to fertility across the lifespan.

3.5. Size and direction of effects

To illustrate effect sizes, we used Stata's *margins* command to compute predicted abortion proportion associated with the mortality/morbidity variables being held at two standard deviations above and below their means. Covariates are held at their existing values in the dataset and a simulation is run for each observation, with the effect then averaged. Results are shown in Figs. 1 and 2. Most apparent are the large effect of morbidity on the under-25 abortion proportion and the small effect sizes elsewhere.

The general reversal of the direction of the effect of mortality and morbidity for age bands over 25 may indicate that despite earlier reproductive onset, harsh ecological conditions may prevent prolonged reproductive careers. One may speculate that individuals do not wish to bring multiple offspring into either a) a dangerous environment or b) into a family where poor health or early mortality is the norm. This may echo Geronimus (1992, 1996b) contention that it is not just a potential mother's health which must be assessed before childbearing; but also that of the wider family, especially in situations where relatives live nearby and assist with caretaking.

Table 5
adjusted regression models show that long-term limiting illness negatively predicts abortion proportion in under-25 s; positively predicts abortion proportion in intermediate age bands; but does not predict 35 and over abortion proportion.

	Under-25 abortion proportion			25–29 abortion proportion			30–34 abortion proportion			35 and over abortion proportion		
	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value	Coef.	Robust Std. Error	p-value
Age-standardised long-term limiting illness prevalence	−2.456	0.212	<0.001	0.780	0.221	<0.001	1.175	0.230	<0.001	0.297	0.257	0.247
Deprivation-related control variables												
Proportion of pop 16–74 with level 4/5 qualifications	3.170	0.097	<0.001	1.582	0.096	<0.001	−0.462	0.091	<0.001	−1.064	0.087	<0.001
Household weekly income	0.000	0.000	<0.001	0.001	0.000	<0.001	0.001	0.000	<0.001	0.000	0.000	<0.001
Urban/Rural (ref: population > 10 K)												
'Town and fringe' wards	−0.121	0.014	<0.001	−0.173	0.016	<0.001	−0.156	0.017	<0.001	−0.096	0.016	<0.001
'Villages hamlets and isolated dwellings' wards	−0.028	0.018	0.113	−0.245	0.020	<0.001	−0.278	0.019	<0.001	−0.201	0.018	<0.001
Proportion of pop 18–64 claiming jobseekers' allowance	2.211	0.537	<0.001	4.241	0.527	<0.001	3.344	0.521	<0.001	1.794	0.569	0.002
Housing tenure:												
Proportion of population renting private housing	0.130	0.124	0.292	0.609	0.099	<0.001	0.634	0.094	<0.001	0.211	0.097	0.029
Proportion of population living rent-free	−0.133	0.555	0.811	−1.755	0.506	0.001	−1.849	0.491	<0.001	−1.818	0.507	<0.001
Proportion of population living in owned housing	0.398	0.056	<0.001	−1.416	0.053	<0.001	−1.337	0.056	<0.001	−0.591	0.057	<0.001
Constant	−1.281	0.087	<0.001	−1.635	0.084	<0.001	−1.342	0.086	<0.001	−0.864	0.091	<0.001

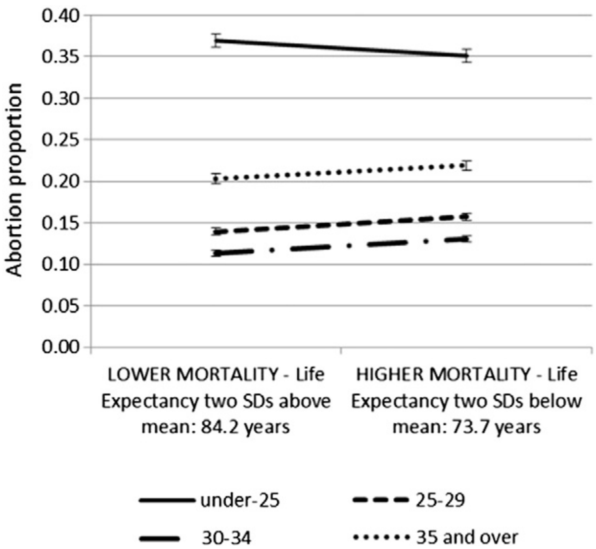

Fig. 1. Adjusted 'abortion proportion' predictions for all age bands in wards with Life Expectancy two standard deviations above and below the mean. Covariates held at values observed in dataset.

The adjusted predictions make clear that for under-25 abortion proportion morbidity has a large effect, all else equal; the effect size for mortality is somewhat smaller. This might be simply because we live in a very low-mortality society. When mortality and morbidity within the UK are assessed using comparable measures like Life Expectancy and Disability-free Life Expectancy, it is known that there are greater socioeconomic differentials in morbidity (Bajekal, 2005). Alternatively, local morbidity might emerge as the stronger predictor because it is more likely to affect females than males (who tend to die younger but suffer fewer unhealthy life years) (Bajekal, 2005). As it is usually females who are more involved with alloparenting, cues to local morbidity (rather than mortality) might be more pertinent to whether a child can be successfully raised. Commencing fertility is a more key life event than continuing fertility since in the latter case some reproductive success is already achieved. There could be a larger effect size for morbidity in the youngest age band because it is these less experienced women who are most reliant on female alloparents for advice and help related to childbearing and childrearing.

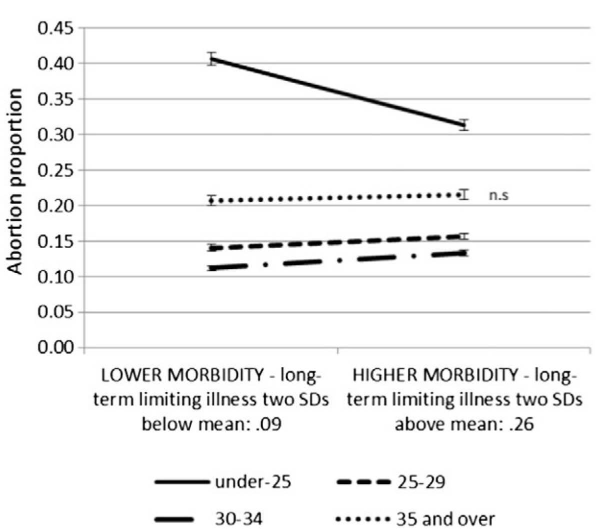

Fig. 2. Adjusted 'abortion proportion' predictions for all age bands in wards with age-standardised long-term limiting illness two standard deviations above and below the mean. Covariates held at values observed in dataset.

3.6. Psychological mechanisms

It is then possible that people have evolved psychological mechanisms which detect morbidity as well as mortality in the locale, which is unsurprising as, although chronic, non-communicable diseases are now most prevalent (Olshansky & Ault, 1986), throughout human history there would have been many indicators of communicable illness, usually leading to death (we reiterate that these psychological mechanisms do not necessarily involve conscious deliberation). The mortality/morbidity 'age flip' suggests that at around age 25 in this particular context, local cues to premature death and elevated ill-health (presumably transmitted visually and via word-of-mouth) stop eliciting the motivation to take a pregnancy to motherhood; and instead start motivating women to terminate pregnancy. In terms of evolved psychological mechanisms, this suggests that the same informational input from the ecology is leading to different behavioural outcomes at different ages. Additional information feeding into such a decision might be both an assessment of the woman's own personal state of health, which is probably more likely to be impaired if she lives in a deprived environment (notwithstanding the ecological fallacy); and the achieved parity of the woman so far. Indeed, accelerated health deterioration and early childbearing have been found to co-occur in a cohort of British women, and the former does not appear to be a consequence of the latter (Nettle, 2014). Gray, Evans, and Reimondos (2013) find that even for childless women a decline in health from fair to poor is associated with a decrease in childbearing desires, as is an increase in age; and with age individual morbidity becomes more likely.

3.7. Proxy cues for high mortality

The small effect sizes for mortality, once other indicators of deprivation are controlled, might indicate that other ecological indicators of deprivation act as proxies for shortened life expectancy. If individuals in the neighbourhood are living in social rented housing, have a low income, do not choose to acquire a tertiary education, and are unemployed, it might be that these cues are computed as proxies for short life expectancy without explicit cues of mortality (e.g. violent crime) being present. The generally small effect sizes are in some ways unsurprising, as there are many contributing factors to the decision to have an abortion. If the effect of mortality or morbidity were greater, the putative phenomenon would no doubt be consciously perceived and widely recognised.

3.8. Deprivation, time and 'abortion proportion'

The regression results also indicate that the socioeconomic variables mostly have a consistent direction of relationship to abortion proportion across the age bands, with some exceptions in the case of education and owned housing. Although in the models unemployment is positively associated with abortion proportion, this is due to collinearity and suppressor effects, as in a correlation matrix the relationship was negative. Therefore this analysis does not simply indicate that 'deprived people have children earlier'. Even this modest disaggregation of socioeconomic status shows that different elements of deprivation are inconstantly related to reproduction (all else equal), but there is unfortunately insufficient space for further discussion of the controls. Our results suggest that deprivation matters over and above either mortality or morbidity risk, which in turn suggests that deprivation is unsurprisingly an indicator of more than just health risks.

Education changes from being a positive predictor of abortion proportion for the younger two age bands to a negative predictor for the older two age bands – clearly a pattern emerging from the time trade-off between education and reproduction. Mortality and morbidity schedules might represent an ultimate time horizon determining reproductive timing and thereby secondary decisions related to accrual of embodied capital. We see that high-mortality/morbidity wards show low under-25 abortion proportion while high-education wards see high under-25 abortion proportion. Life expectancy has a Spearman correlation of .44 with the education variable, while long-term limiting illness has one of − .67. High mortality/morbidity indicates low education and low abortion proportion, consistent with the idea that perceived health/lifespan could affect early reproductive scheduling and thereby education decisions. McLanahan (2004) shows that in the most developed countries life trajectories between the most-educated and least-educated women have drastically diverged in recent decades, meaning increasing inequality in resources (e.g. wealth; presence of an investing father) for their offspring. Although she speculates on four causes, i.e. feminism, new birth control technologies (including the Pill and abortion); changes in the labour market; and welfare policies, this does not fully explain why becoming educated is of differential interest to women of different socioeconomic backgrounds in the first place. This could be explained by differential time horizons from unequal mortality/morbidity cues. However, direction of causality (if any) between ward-level mortality/morbidity, under-25 abortion proportion, and ward-level education is not known. It is equally possible that perceived individual returns to education might affect reproductive scheduling; and much public health literature discusses the possible causal role education plays in health (Lynch, 2003; Schillinger, Barton, Karter, Wang, & Adler, 2006).

3.9. Limitations

There are some limitations to our study. A ward measure of 'access to services' (distance from a post office; food shops; a GP; a primary school) was unavailable for this time period. There is some overlap in its content and those measuring provision of contraception and abortion services, in that initial consultation with a GP is a route to abortion referral. However, specific abortion provision (referral, consultation and procedure) has not been associated with abortion proportion, although the percentage of female GPs in a local authority was predictive in final models of one study (Lee et al., 2004). In general, therefore, there is no strong reason to think that access to services might especially influence abortion proportion.

The ecological fallacy means that any apparent relationship between mortality/morbidity and abortion proportion should be cautiously appraised because those experiencing the average ward level of mortality/morbidity might not be those who are choosing whether to terminate a pregnancy while residing there. However, the theoretical underpinning of this paper means that we assume women are picking up not only their own experience of death or disease, but also area-level cues indicating actual or likely death or disease in both loved ones (to gauge their availability for childcare) and strangers (to gauge general safety). Cues to mortality might assay the prevalence of violent street crime, with young males more often homicide victims (Office for National Statistics, 2013a, 2013b). These cues might be discounted by a young pregnant woman who does not feel that her future holds the possibility of moving to a 'better' area; and who might have nearby family offering childrearing support such that paternal investment from a reliable male is not crucial. Morbidity itself might be more likely to affect the young woman herself, or potential caretakers for offspring like female friends or relatives. It is not necessary for our hypothesis, then, that those making reproductive decisions are exactly the same individuals experiencing death or disease. Therefore the concerns raised by ecological fallacy are here somewhat mitigated; and the relatively small size of wards also helps.

What we can say about how conditions in an individual's residential ward might affect their reproductive behaviour remains partial, nevertheless. People's day-to-day geographical mobility (e.g. for work) means that they might not be affected by mortality/morbidity cues close to home, and the extent of this might also vary with socioeconomic status. Wards also might not be coterminous with the area people experience as their neighbourhood. Additionally, if someone moves house between learning of a pregnancy and starting/continuing a family, it could be said that the initial cues might not be at a consistent level to those in the new residential ward where the birth occurs. Yet as there is low social mobility in the UK within and between generations (Hills et al., 2010) individuals are likely to move to areas with similar deprivation and health levels. Finally, in terms of limitations, the abortion proportion variable offers no information regarding parity; the lack of raw numerators and denominators means one must necessarily compare wards with low and high conception base rates; and the cross-sectional nature of the data mean that causality cannot be inferred.

Finally, we use an overall measure of mortality and morbidity, rather than focus exclusively on extrinsic mortality, although the life history prediction states that higher extrinsic mortality should shift individuals towards a 'faster' life history. This is because in practice it is very difficult to separate extrinsic (that outside of one's control) from intrinsic (within one's control) mortality: if extrinsic mortality is high then there are fewer benefits to investing effort in controlling one's mortality risk by, for example, adopting healthier and less risky behaviours. We make the simple, and likely, realistic assumption, that higher overall mortality/morbidity represents an increase in extrinsic mortality risk, regardless of the exact composition of mortality in terms of its extrinsic/intrinsic nature.

4. Conclusion

In summary, mortality has small but consistent effects in predicting abortion proportion across age bands: lower in under-25 s (in line with predictions derived from life history theory), consistent with a role in stimulating early fertility; and higher in older age bands. Elevated morbidity predicts lower under-25 abortion proportion with a larger effect size, consistent with the weathering hypothesis and possibly indicating its greater salience for reproductive aged women in low-mortality societies. It also has small effects on intermediate age bands' abortion proportion, with poor ward-level health predicting more abortion. However, it has no relationship with abortion proportion in women 35 and over, which may point to greater concerns with potential offspring health at this point in the lifespan. Future research should explore individual-level psychological mechanisms mediating any assumed causation.

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Appendix A. How wards of different types were merged

Wards were the geographical unit of analysis. However, in terms of available variables, there is more than one type of ward: Census Area Statistics (CAS) wards, 2003 wards, and Standard Table (ST) wards. This is due to the smaller 2003 or CAS wards in some cases having been merged into the larger ST wards to aid confidentiality. In the main, nevertheless, the different ward types describe the same geographical entities. As the main independent variable, life expectancy, was only available at ST ward level, this ward type dictated the initial N. Then exclusions were made where Office for National Statistics information indicated that mergers had made wards with the same ID numbers non-identical. For further information, see http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/administrative/england/electoral-wards-divisions/statistical-wards–cas-wards-and-st-wards/index.html.

Appendix B. Variables used in the analysis.

Variable	Source and type of ward, time period measured	Comments
Independent variables		
Mortality measure		
Life expectancy	Office for National Statistics ('experimental' data) Standard Table ward 1999–2003	Constructed from abridged life tables. Average number of years a newborn baby would survive if he or she experienced the ward's age-specific mortality rates for that time period throughout his or her life. Aggregated 1999–2003.
Morbidity measure		
Age-standardised long-term limiting illness prevalence (LTLI)	Census 2001 Census Area Statistics ward April 2001, referring to previous 12 months	Derived from prevalence of long-term limiting illness in population and multiplied by proportion of individuals in that age band in England & Wales in 2001. Age-specific totals then summed. Expressed as a proportion between 0 and 1.
Dependent variable		
'Abortion proportion' for age bands: under 25, 25–29, 30–34, 35 and over, all ages	Office for National Statistics CAS wards 1999–2003	Proportion of conceptions ending in abortion
Covariates		
Proportion of persons living in medical and care establishments	Office for National Statistics ('experimental' data) Standard Table ward 1999–2003	
NB: used only in models featuring life expectancy as independent variable		Categorical variable in quintiles ranging from 0 (none) to 5 (many)
Urban/rural	Office for National Statistics CAS ward March 2004	Dummy variable with three settlement types: 1 = urban ward with population greater than 10 K 2 = 'town and fringe' ward 3 = villages, hamlets and isolated dwellings Reference category: 1
Proportion of people aged 16 to 74 with level 4 and 5 qualifications (e.g. first degree; higher degree; NVQ levels 4 and 5; HNC; HND; Qualified Teacher Status; Qualified Medical Doctor; Qualified Dentist; Qualified Nurse; Midwife; Health Visitor)	Census 2001 CAS ward April 2001	Index of educational level across all age groups in an area, which meant it would be meaningful for all age groups of the 'abortion proportion' dependent variable. Arguably an index of expectations regarding educational attainment in an area.
Proportion of people aged 18 to 64 claiming jobseekers' allowance	Department for Work and Pensions 2003 ward 'snapshot' data, August 2001	Used in preference to an index of unemployment, as those not only unemployed but also claiming unemployment benefits will also be impoverished rather than simply choosing not to work.
Average weekly household net income estimate equivalised after housing costs	Office for National Statistics 2003 ward 1st April 2001 to 31st March 2002	Household income with household size and local housing costs adjusted for to create a proxy measure of individual welfare. Model-based estimate combining survey data with census and administrative data.
Proportion of people of each type of housing tenure (owner-occupied, social rented housing, privately rented housing, rent-free)	Census 2001 CAS ward April 2001	
Proportion of people of each different religion or none/not stated	Census 2001 CAS ward April 2001	
Proportion of people of each different ethnicity	Census 2001 CAS ward April 2001	

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