Reduced birth intervals following the birth of children with long-term illness: evidence supporting a conditional evolved response

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Human birth interval length is indicative of the level of parental investment that a child will receive: a short interval following birth means that parental resources must be split with a younger sibling during a period when the older sibling remains highly dependent on their parents. From a life-history theoretical perspective, it is likely that there are evolved mechanisms that serve to maximize fitness depending on context. One context that would be expected to result in short birth intervals, and lowered parental investment, is after a child with low expected fitness is born. Here, data drawn from a longitudinal British birth cohort study were used to test whether birth intervals were shorter following the birth of a child diagnosed by a medical professional with a severe but non-fatal medical condition. Data on the timing of 4543 births were analysed using discrete-time event history analysis. The results were consistent with the hypothesis: birth intervals were shorter following the birth of a child diagnosed by a medical professional with a severe but non-fatal medical condition. Covariates in the analysis were also significantly associated with birth interval length: births of twins or multiple births, and relationship break-up were associated with significantly longer birth intervals.

1. Introduction

The length of birth intervals is influenced by an array of behavioural factors, including infant feeding practices that affect suckling-induced anovulation, cultural practices surrounding sex such as postpartum sexual abstinence, and the use of birth control and its effectiveness [1,2]. From a life-history theoretical perspective, birth intervals are under evolutionary selection pressure as an aspect of the trade-off between quantity and quality of offspring, and so these behavioural factors affect parental fitness [3]. Birth spacing that is too close has costs for offspring quality, because parents cannot simultaneously care for two or more young and highly dependent children without compromising their mortality risk, health and growth. In life-history theory, birth interval can thus be seen as an index of parental investment [4]. There is empirical evidence for these costs of short spacing: very short birth intervals (less than 2 years) associate with higher child mortality for both the older and younger sibling [5,6]. At the other end of the spectrum, long birth spacing results in too few offspring produced for the amount of parental resources available, and therefore, there will be an optimum spacing of births somewhere in between.

Mathematical modelling and experimental studies in non-humans of the interval between breeding attempts suggest that close spacing of births not only results in reduced parental investment in the offspring born first, but additionally also minimizes the contribution of the first born to parental fitness [7]. Given these theoretical arguments, a condition that should favour short birth spacing is the birth of an offspring with low expected fitness: parents can minimize the fitness costs of producing a child with low expected fitness by following the birth with a...
short birth interval. Consistent with this, Bereczkei [8] found that shorter birth-spacing followed the birth of low birth-weight infants born with health problems. The prediction tested in the research reported here is that birth intervals will be shorter after the birth of any child with a disabling but usually non-fatals physical or mental condition, because parents would be expected to shift their focus from investment in a disabled child to future, potentially more reproductively viable offspring.

2. Methods

(a) Sample

Data were drawn from the British longitudinal cohort study of all children born in a one-week period in April 1970 (the BC570 sample). The 2004 BC570 data included a database that focused on live-born children (the parent and child database), and the child health data for this study were drawn from this [9]. Birth interval data are complete up to 2012, when participants were 42 years old. Further information on the sample is available from the Centre for Longitudinal Studies (see reference [9]).

(b) Independent variables

A binary variable was constructed to denote the presence of disabling medical conditions at birth using ICD-10 codes (see http://www.cdc.gov/nchs/icd/icd10.htm) recorded by the interviewer. Birth interval length is likely to be affected by a number of life-history and reproductive variables that can be statistically controlled for using the BC570 data. Completed family size in 2012, birth order, and the age of the parent at the birth of the child may influence birth intervals, and were included as covariates. Given that most births are likely to be to parents in a marriage or partnership, marital or relationship break-up in the birth interval was recorded as a binary control variable. The sex of the parent and of the child were included as binary covariates. Because social class is often associated with reproduction [10], parental socioeconomic status (SES) was included as a covariate in the statistical model. SES data were coded using the 1980 Registrar General’s classification of social class based on occupation [11]. The SES of the head of household in which child lived was used. If the father was absent or not employed, and the mother was working, then the mother’s SES classification was used.

(c) Dependent variable and statistical analysis

The data had a two-level structure of one or more births occurring to individual parents, hence multilevel modelling was used. Because there were right-censored observations where parents did not have another child by age 42 (the last data collection sweep in the cohort study), and these observations may add important information about birth intervals, analysis of all birth intervals including right-censored intervals was carried out using discrete-time event history analysis (xtlogit procedure in STATA, release 14 [12]). The dependent variable can be interpreted as the hazard of birth, where an increased birth hazard associated with an independent variable has a positive sign and indicates a shorter birth interval length. Unobserved heterogeneity was handled by treating the data as panel data including a random effect (sigma_u).

Model selection was carried out by forward selection, adding in control variables one by one and retaining them if they significantly improved the model fit (a significant improvement to the model − 2 logL). Presence of a serious illness was then entered into the model, followed by interaction effects between chronic illness and each control variable one by one, retaining them if they improved the model fit.

3. Results

(a) Descriptive statistics

Data were complete for all study variables for 4543 births to 2992 parents. Fifty-four per cent of birth intervals were followed by another birth, with closed birth intervals averaging 41 months apart (s.d. = 28 months). Four hundred and fifty-three birth intervals were shorter than 24 months, which is the minimum birth spacing recommended by the World Health Organization [13]. ICD-10 codes for the following medical conditions were reported and included as disabilities in constructing the binary variable indicating presence of a serious disability diagnosed before age one: mental retardation (e.g. diagnosed in infancy using dysmorphic features); congenital dwarfism; absence or malformation of body parts or organs (e.g. club-foot, cleft palate); neural tube defects; trisomy and other chromosomal abnormalities; septal defects; fimbriocystic disease; Sjögren-Larsson syndrome; Apert syndrome; Epstein’s syndrome; severe cerebral palsy; profound deafness; blindness. Seventy-seven births were recorded with these disabilities.

The mean and range for each independent variable are included in table 1. Of note, it can be seen that women were more likely to provide data on their reproductive histories than men.

(b) Discrete-time event history analysis

Results of the discrete-time event history analysis of the hazard of birth are shown in table 2. Two variables were found to be

<table>
<thead>
<tr>
<th>independent variable</th>
<th>mean</th>
<th>s.d.</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td>parent’s sex (1 = F, 2 = M)</td>
<td>1.37</td>
<td>0.48</td>
<td>1–2</td>
</tr>
<tr>
<td>child’s sex (1 = M, 2 = F)</td>
<td>1.49</td>
<td>0.50</td>
<td>1–2</td>
</tr>
<tr>
<td>family socioeconomic status (1 = highest)</td>
<td>2.88</td>
<td>0.92</td>
<td>1–5</td>
</tr>
<tr>
<td>completed family size in 2012</td>
<td>2.43</td>
<td>1.01</td>
<td>1–8</td>
</tr>
<tr>
<td>birth order</td>
<td>1.57</td>
<td>0.81</td>
<td>1–7</td>
</tr>
<tr>
<td>break-up in interval (1 = no, 2 = yes)</td>
<td>1.11</td>
<td>0.10</td>
<td>1–2</td>
</tr>
<tr>
<td>multiple birth (1 = no, 2 = yes)</td>
<td>1.02</td>
<td>0.10</td>
<td>1–2</td>
</tr>
<tr>
<td>serious health problem diagnosed &lt; 1 (1 = no, 2 = yes)</td>
<td>1.01</td>
<td>0.12</td>
<td>1–2</td>
</tr>
</tbody>
</table>
collinear: birth order and completed family size. This was handled by converting birth order into a binary variable split at 3. Being a fourth-born child or later in the birth order was associated with a reduced likelihood of birth or longer birth intervals. The sex of the parent and child, SES and the parent’s age were not significant predictors of the hazard of birth in the final model. The hazard of birth was significantly greater after a child born with a serious medical condition, and was lower after the birth of twins/multiple births. The model predicted that by 24 months, 10% of parents who had a child with a serious health condition had another child, as opposed to just over 5% of those who had a child without a health condition. Experiencing marital/relationship dissolution was associated with a reduced birth hazard. One interaction effect of being born with a chronic illness was significant: there was a negative interaction with completed family size. This occurred because larger families responded differently to small families to having a child born with a chronic illness: small families followed the birth of a chronically ill child with an increased hazard of birth, whereas large families followed these births with a reduced hazard. To further investigate this interaction and assess whether it was linear, family size was recoded as dummy variables for each completed family size. Completed family sizes of more than four children were collapsed into a single category of four or more children, and variables were created for each interaction with having a chronically ill child. Discrete-time event history analysis showed that the interaction was roughly linear (from a completed family size of two children), negatively associated with hazard of birth and statistically significant at a completed family size of three children (odds ratio = 0.351, coeff. = 0.188, \( z = -1.96, p = 0.05 \)). This suggests that parents with a completed family size of two children, which was the modal completed family size in the sample, were the most likely to follow the birth of a child with a serious medical condition with a short birth interval.

4. Discussion and conclusion

The results supported the hypothesis that a child with a chronic health condition would be followed by a shorter birth interval: the odds ratio (2.12; table 2) showed that the birth of a child with a health condition doubled the monthly probability of having a next child. This effect appears to be moderated by completed family size: there was a larger effect in small completed families. The results were consistent with prior work by Bereczkei [8], who found that shorter birth-spacing followed the birth of low birth-weight infants born with health problems, and at a broader level are compatible with the underlying evolutionary life-history theoretical perspective that parents will attempt to space births to maximize reproductive success [3,14]. A clinical implication of the result is that medical practitioners could consider interventions aimed at persuading parents with a chronically ill infant to wait longer before attempting to have another child, although recent evidence suggests that the adverse health effects for children of close birth spacing may not be as great in well-fed modern populations, and that methodological problems in earlier studies have tended to overestimate the negative health consequences [15].

Several control variables were found to be significant predictors of birth intervals or the hazard of birth. The hazard of birth was substantially lower after the birth of twins or multiple births, suggesting maternal depletion and/or high costs of parentally caring for multiple offspring simultaneously. This finding is consistent with evolutionary studies of the high fitness costs of twinning [16]. Marital or relationship dissolution occurring during a birth interval also reduced the hazard of birth, which is consistent with past research on the determinants of fertility [17]. It also suggests that there may be a fitness cost to marital dissolution; that marital dissolution on average leads to a lower hazard of birth as opposed to new mating opportunities, remarriage and pregnancy.

Ethics. Ethics and confidentiality information can be accessed via the UK Data Service.

Data accessibility. All raw data used in the research are available from the UK Data Service. At the time of publication of this paper, the raw data can be accessed at http://discover.ukdataservice.ac.uk/series/?sn=200001#access. Downloading the data requires free registration with the UK Data Service. Registration information can be found at http://ukdataservice.ac.uk/get-data/how-to-access/registration/uk-he-fe-users

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References


