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Kin-based alloparenting and infant hospital admissions in the UK Millennium cohort

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ABSTRACT

Background and objectives: Kin-selected altruism is an evolutionary explanation for why biological kin other than parents are willing childcare providers or alloparents. Kin alloparents may increase lineage fitness by reducing maternal energy depletion and improving child survival through childcare activities. The aim of this research was to apply the hypothesis that kin-based alloparental care has benefits for child health in a western, educated, industrialized, rich, democratic context.

Methodology: The hypothesis was tested using the first sweep of the UK Millennium Cohort Study ($n = 18\,552$ infants). The outcome was number of hospitalizations by age 9 months, and the main predictors were kin-based alloparental care during work hours, socioeconomic position and infant health-related variables and their interactions with kin-based alloparenting. Analysis of hospitalizations was carried out using negative binomial regression.

Results: Kin alloparents were primary day carers in 17% of households. Infants whose main care arrangement during work hours was with kin allocarers had statistically significantly fewer hospitalizations than infants in all other care arrangements combined (Incidence rate ratio = 0.86, $P < 0.03$), and when contrasted with maternal day care (Incidence rate ratio = 0.79, $P < 0.02$).

Conclusions and implications: Kin-based allocare was associated with about a 15% reduction in the risk of infant hospitalization in the first 9 months. The difference appeared to be due in part to a difference in the risk of hospitalization for infectious diseases. Sensitivity analyses indicated that infants cared for by their mother during the day rather than in day-care facilities were most at risk of hospitalization compared with those in kin-based care.

Lay summary: Modern industrialized societies are generally characterized by nuclear family households, with grandparents and other extended family often living a considerable distance away. Studies carried out in societies which have not undergone the fragmentation of extended families have shown that grandmothers and other biological kin reduce infant mortality, most likely because they distribute the burden of infant care so that it does not fall exclusively on the mother. Here, the hypothesis that grandparental and other family care would be beneficial for infant health in the contemporary UK was

testing using the UK Millennium cohort. Infant health was measured as number of hospitalizations in the first 9 months from birth. The main findings were that kin-based infant care, which was most commonly by grandparents, was associated with a 15% reduction in the risk of hospitalization in infants up to 9 months of age. Further analysis suggested that the difference was larger for risk of infant hospitalization due to infectious diseases rather than non-infectious diseases. The results also suggested that the finding may have been driven by increased risk for infants of mothers caring for their infant during normal working hours with no other help, such as from the father or pay-for day-care.

KEYWORDS: kin help; grandparents; morbidity; infant health; childcare

INTRODUCTION

Alloparenting is defined as provision of care for infants and children by individuals other than by their parents [1]. Alloparenting is widespread in birds and mammals including primates [2]. Humans as a species are characterized by reliance on communities and biological kin in particular to help raise children and ease the burden of motherhood [3, 4]. This study tested the hypothesis that kin-based alloparental help is associated with a lowered risk of serious illness in infants.

Most human societies have been characterized by the presence of extended family including grandmothers and other potential kin-alloparents [2–4]. The pattern in industrialized economies has shifted towards nuclear family living, and for many, moving away from extended family to where employment is located. Many of these societies have become known in the social sciences by the acronym 'WEIRD', which stands for Western, educated, industrialized, rich, and democratic [5]. Despite the predominance of nuclear family living and the geographical break-up of biological kin networks in WEIRD societies, in the UK 63% of grandparents provide some childcare, and the European average is 44% [6]. This suggests that grandparental allocare remains a common practice in WEIRD societies.

Kin-based alloparenting has been a focus of study in evolutionary biology because it can increase both the reproductive success of parents and the fitness of allocarers who are genetic kin: parents freed of the burden of infant care can invest their time in other activities which will increase their future reproduction, and kin-allocarers gain if their care reduces infant morbidity and mortality risk. While unrelated allocarers could gain through reciprocal benefits of altruistic behaviour in their community, kin-based help does not require reciprocal altruism due to the inherent interest that individuals have in the reproduction of their genetic kin [7]. Kin selection including kin-based allocare has been argued to operate socially and psychologically through feelings of obligation towards kin, and by being socially imposed through cultural practices [8].

Reproductive and evolutionary benefits of kin-based alloparenting can theoretically accrue through two routes: increasing the number of children and by reducing child mortality. The latter route appears to be more important in human societies, and there is substantial evidence that grandmothers in particular as a class of alloparent reduce infant and child mortality in nations which tend to have high infant mortality [9]. In WEIRD societies, the relationship between kin-based allocare and child health is less clear, and infant mortality is a rare event. There is evidence that kin-based allocare reduces maternal depletion resulting in closer birth spacing and decisions to have larger families [10–18], but also a number of studies which show no evidence for or negative associations between kin-based allocare and measures of women's fertility [15, 16, 18–24]. There is little evidence for and few studies testing the hypothesis that kin-based alloparental support leads to better infant health in WEIRD societies, or on what types of disease kin-allocarers could avoid or protect infants against [25, 26]. In the UK Millennium cohort, grandparental involvement has been found to associate with higher infant weight for age, perhaps suggesting nutritional and growth advantage, although childhood obesity is not likely to be currently advantageous [27]. Co-residence with a grandparent in the Millennium cohort has been found to be associated with reduced risk of injury [24]. Under WEIRD conditions alloparenting is unlikely to lead to reduced infant mortality, but it may remain important in reducing morbidity, particularly for infants who are vulnerable, for example due to being born after a close birth interval, low birthweight or born after a difficult labour.

Predictions

The main prediction tested here was that kin-based allocare will be associated with reduced infant morbidity in the Millennium Cohort, a WEIRD sample from the UK (henceforth MCS). This should be the case because genetic kin would be predicted to be more likely to provide high quality care due to kin-selected fitness advantages: all else being equal, a 60-year-old grandmother has more incentive to provide high-quality care than a 60-year-old day-care centre employee, due to the genetic stake that the grandmother has in the infant [28]. All biological kin identified by the main care-provider were counted as kin allocarers in this research. Two alternative hypotheses were included, both straightforward interpretations of kin selection theory. First, all biological kin should provide higher-quality infant care than all non-kin; and second, parents should provide higher-quality care than any other carers because parents have

the highest degree of genetic relatedness to their offspring. Therefore, it was predicted that all kin care (including parents and relatives) and parental care would be associated with lower infant morbidity. Second, it tested the prediction that kin-based allocare would have the largest effect on reducing morbidity in more vulnerable infants. This is because the potential benefit to higher quality infant care is likely to be greater if the infant is particularly at risk of illness, for example, if s/he had a low birthweight.

METHODS

Population and sample

The MCS, which consisted of 18 552 infants born from September 2000 to August 2001 was used to test the study hypotheses. Data were analysed using the first survey of the cohort, which took place when the infants were around 9 months old. A cohort profile of the MCS is available providing detail about the sample and sampling methods [29]. Data were available for all study variables included in the main regression analysis for 18 290 infants.

Dependent variable

The intended focus of the research was serious medical conditions with potentially fitness-reducing consequences. The MCS first sweep contains health-related data on the type and number of illnesses experienced by the cohort members. Hospitalization involves both caregiver and medical practitioner decisions, and of the available MCS health variables is most likely to capture serious illness without including cases of minor illness. The main dependent variable was the number of hospitalizations in the first 9 months after birth, reported by the main caregiver.

Independent variables

The predictor variable testing the study hypothesis was a binary variable indicating whether or not the infant's main daytime care provider is a grandparent or other relative. Weekday care was selected because this is when most parents face the greatest infant care constraints and time conflicts with paid employment or education. This variable contrasts family-based allocare with all other care, including paid-for day care at a day-care centre and infant care by the mother herself.

Covariates for statistical models were selected based on prior research demonstrating key importance as determinants of infant health and availability in the MCS data. Low birth weight is an important risk factor for infant mortality and morbidity [30], and additionally captures a second risk factor for infant mortality: gestational age at birth, as premature infants are also born with lower birthweight. The baby's presentation (e.g. breech birth) additionally predicts health problems in neonates [31, 32], and in the MCS is captured by a binary variable representing any problem during labour versus no problems. The baby's sex was included as a covariate because being male is associated with health problems in infancy [33]. Short intervals between births lead to maternal depletion and poorer child health outcomes [34]. Birth interval was categorized into quartiles with first births coded as '5'. Socioeconomic position and father absence are also associated with higher health risk in infancy [35]. Socioeconomic status was operationalized by the age that the mother left full-time education, and using McClement's equivalency scale, a household income equivalence scale which adjusts household income for household composition based on the number of individuals in a household and their ages [36]. Missing values for income were assumed to be randomly distributed and were assigned the mean value. Maternal age has a U-shaped association with infant mortality and morbidity, with infants born to mothers over 40 having around a 3-fold increased risk of infant mortality when compared with the lowest risk maternal age [32]. Some maternal pre-existing health conditions (such as diabetes), additionally have large effects on infant health [32]. In the MCS data, maternal longstanding illness is represented by a binary variable. A mother's need for allocare during work hours will depend greatly on whether she is employed or in education. A binary variable was created of women's work or full-time education versus not being in work or education. The cohort member's age in days at interview was included in the statistical models, as not all infants were exactly the same age when their parent was interviewed.

Interaction effects were included between the presence of kin-based alloparenting and risk-factors for poor infant health that are available from the first sweep of the MCS. These interaction effects test whether alloparental childcare is particularly beneficial for fragile infants, identified here as infants born to mothers with longstanding illness, a difficult labour and delivery, low socioeconomic position and education, low birth weight, young maternal age, short birth intervals, father absence from the household or being a male infant. All interaction effects were orthogonalized (residual centred) to avoid collinearity with the original variables in the regression analyses.

Statistical models

Analysis was carried out using negative binomial regression, as the outcome variable, number of hospitalizations, has an overdispersed Poisson distribution. Prior to final analysis, potential curvilinear relationships with infant morbidity were explored by creating quadratic terms in regression models predicting

number of infant hospitalizations. For example, maternal age may be a risk factor for infant morbidity at early and at late ages at birth, with an intermediate optimum age. One quadratic term, birth weight squared, was a statistically significant predictor of hospitalizations ($P < 0.01$), and was included in the final analyses.

Six sets of sensitivity analyses were carried out to test whether associations between kin-based alloparental care and number of hospitalizations were robust to different modelling decisions. First, sensitivity analyses were performed to contrast alloparenting solely with care in pay-for day-care facilities, care by the biological father, and day care by the mother herself. Second, because the main model contained a relatively large number of variables and hence may be over-specified, interaction terms were removed from the model. Third, to help confirm causal direction: that kin-allocare leads to poorer health outcomes rather than infants in good health being more likely to be cared for by allocarers, additional covariates were added to the model which represent aspects of infant and maternal health, and the difficulty of the birth process itself. The reasoning behind this approach was that if kin-allocare leads to a difference in the risk of hospitalization and not vice versa, kin-based allocare should remain statistically significant when controlling as completely as possible for neonatal health status and health risk. The MCS variables added were: whether the infant was conceived using assisted reproductive technologies, which is associated with infant health [37]; normal versus assisted delivery (e.g. forceps); duration of labour; number of pharmacological pain interventions during labour; length of mother's hospital stay after birthing; whether the mother received antenatal care; number of hospitalizations for accidents or injuries during infancy and the mother's rating of whether she lives in a dirty, polluted environment. Interaction effects with allocare were not included in this analysis. Fourth, to test whether kin allocare effects were likely to be due to grandparental care rather than all kin-based care, a model was run with grandparental care as an independent variable in place on kin-based allocare. Fifth, the outcome data were split into two separate variables to test whether effects of allocare were present for both infectious and non-infectious disease, as the MCS recorded reason for admission for the first four hospital admissions for each infant. These tests address whether kin-allocare is associated with exposure to pathogens as opposed to offering protection from other (non-infectious) disease. Lastly, the models were run using another appropriate statistical technique, generalized linear models with a gamma variance function and a log link function. All statistical tests were carried out using Stata 16, including generation of tables and graphs. The coefficient plot add-on program for Stata was created by Jann [38]. Table 5 and the appendix tables were created using the asdoc program for Stata [39].

RESULTS

Descriptive statistics

Descriptive statistics for the study variables are displayed in Table 1. Tables 2 and 3 summarize which categories of individual most commonly provided daytime infant care, and the most commonly reported reasons for the infants' hospital admissions. Table 3 shows that although the vast majority of working-hours infant care was provided by parents, kin-based allocare was a common occurrence (17% of infants were in kin-based allocare). Table 4 displays correlations between alloparenting, maternal employment status, maternal age, father absence and the two socioeconomic status measures. Mothers relying on alloparental help were more likely to be employed, had higher socioeconomic status and more years of education. The close correlation between using kin-based allocare with working mothers raised the possibility of problematic collinearity in multivariate models including both variables. To explore this potential collinearity, a further negative binomial regression model was run without maternal employment to compare with regression coefficients from the model including maternal employment (see regression results below).

Regression results

Daytime alloparental care was statistically significantly associated with fewer hospitalizations in the first 9 months of childhood (Table 5 and Fig. 1). Neither of the alternative hypotheses derived from kin selection theory were supported. Figure 1 additionally shows the predicted number of hospital admissions for children cared for by parents, and by all kin. The estimates in Fig. 1 were derived from two negative binomial regression models identical to the one shown in Table 5, but replacing kin-based allocare with parental care, and with all kin-based care and interactions. In a model reducing collinearity by excluding the maternal work variable, kin-based allocare had a slightly stronger association with fewer hospital admissions (IRR = 0.835, $P = 0.003$, CI 0.741–0.941).

All main effects of risk factors for poor health in infancy other than maternal employment and birth interval were also associated with risk of hospital admission (see Table 5). The effect of McClement's equivalency score was opposite to the predicted direction: socioeconomic position was positively associated with number of hospitalizations. Further analysis demonstrated that this unexpected result was due to collinearity between father absence from the household and socioeconomic position: the tetrachoric correlation coefficient between these independent variables was $r = 0.31$ (father absence from the household was associated with lower equivalency scores). A likely reason for this sign reversal is that father absence is on

Table 1. Summary statistics for the study variables

Summary statistics	*N*	Mean	Min	Max	Standard deviation
Infant's number of hospital admissions	18 529	0.19	0	20	0.62
Inter-birth interval quartile category	18 527	3.79	1	5	27.82
Infant's age in days	18 552	295.49	243	382	15.25
McClement's equivalency score	18 552	297.99	14.31	1250.78	227.33
Age mother left full-time education	18 439	17.580	5	36	2.848
Infant birth weight (kg)	18 482	3.344	0.391	7.229	0.590
Mother's birth year	18 546	1971	1949	1987	5.952

		% Yes	% No
Any problems during labour (1 = *Y*, 2 = *N*)	18 497	32	68
Infant kin alloparented in work hours (1 = *N*, 2 = *Y*)	18 507	17	83
Maternal longstanding illness (1 = *Y*, 2 = *N*)	18 524	21	79
Mother employed or in education (1 = *N*, 2 = *Y*)	18 499	45	55
Father absent from household at 9 months (1 = *Y*, 2 = *N*)	18 522	17	83
Infant's sex (1 = M, 2 = F)	18 552	51M	49F

Table 2. Five most frequently reported categories of reason for hospital admission ($n = 18\,529$ infants and 2694 hospital admissions)

Reason for hospital admission for the five most common illnesses	Number of cases	% of admissions
Chest infection or pneumonia	901	33
Breathing problems, wheezing or asthma	359	13
Gastroenteritis	296	11
Severe or persistent vomiting, reflux or other vomiting	214	8
High temperature/acute viral infection (unspecified)	160	6

Table 3. Frequencies of allocare ($n = 18\,507$ infants)

Kin allocare provider during work hours	Number of cases	% of children
Maternal grandmother	1917	10
Paternal grandmother	669	4
Maternal grandfather	83	0.4
Paternal grandfather	25	0.1
Other relatives	441	2
All non-kin day care	2455	13

the causal pathway to socioeconomic status [40]. Removal of father absence from the model resulted in McClement's equivalency score falling below the statistical significance threshold of $P < 0.05$.

None of the interactions between allocare and the covariates were statistically significant (see Table 5). This suggests that kin-based allocare was not more advantageous for infants with health problems or those born after a difficult labour.

Table 4. Bivariate correlations between independent variables and whether kin-based allocare was the main infant day-care arrangement

Covariate	Correlation with kin-based allocare
Mother employed (1 = *N*, 2 = *Y*)	0.482***
Equivalency score	0.099***
Age left full-time education	0.045***
Mother's birth year	0.005
Mother's longstanding illness (1 = *Y*, 2 = *N*)	0.045***
Father not present in household (1 = *Y*, 2 = *N*)	0.060**
Baby's birth weight	0.033**
Baby's sex (1 = M, 2 = F)	−0.004
Problems during labour (1 = Y, 2 = N)	−0.029**

***$P < 0.01$; **$P < 0.05$; *$P < 0.1$.

Table 5. Results of the main negative binomial regression model predicting number of hospitalizations in infancy ($n = 18\ 290$)

Dependent variable: Number of hospital admissions	IRR	Table 5St.Err.	*z* value	*P* value	95% conf. interval	Sig
Kin allocare in work hours (1 = *N*, 2 = *Y*)	0.857	0.585	−2.26	0.024	0.750–0.980	**
Problems during labour 1 = *Y*, 2 = *N*	0.812	0.036	−4.71	0.000	0.744–0.885	***
Baby's birth weight (kg)	0.736	0.026	−8.80	0.000	0.687–0.788	***
Birth weight squared (resids)	0.896	0.016	−6.03	0.000	0.865–0.929	***
Birth interval quartile	0.975	0.016	−1.51	0.131	0.944–1.007	
McClement's Equivalency score	1.389	0.151	3.02	0.000	1.122–1.719	***
Age mother left full-time education	0.967	0.008	−4.11	0.000	0.952–0.983	***
Mother long-term illness (1 = *Y*, 2 = *N*)	0.764	0.037	−5.59	0.000	0.695–0.840	***
Mother employed or in education (1 = *N*, 2 = *Y*)	0.961	0.051	−0.75	0.451	0.867–1.066	
Baby's sex (1 = M, 2 = F)	0.747	0.031	−6.96	0.000	0.688–0.811	***
Father absent (1 = *Y*, 2 = *N*)	0.768	0.052	−3.93	0.000	0.674–0.876	***
Mother's birth year	1.033	0.004	7.96	0.000	1.025–1.042	***
Infant's age in days	1.003	0.001	2.44	0.015	1.006–1.006	**
Allocare*Father absent (resids)	1.021	0.023	0.92	0.357	0.977–1.067	
Allocare*Age left education (resids)	1.026	0.024	1.12	0.265	0.981–1.074	
Allocare*McClements score (resids)	1.012	0.038	0.33	0.742	0.941–1.090	
Allocare*Probs during labour (resids)	1.020	0.022	0.90	0.370	0.977–1.065	
Allocare*Mother's illness (resids)	0.999	0.021	−0.06	0.949	0.959–1.040	
Allocare*Baby's sex (resids)	1.032	0.023	1.41	0.157	0.989–1.078	
Allocare*Mother's age (resids)	1.034	0.025	1.42	0.156	0.987–1.084	
Allocare*Birth weight (resids)	1.022	0.020	1.07	0.286	0.982–1.063	
Allocare*Birth interval quartile (resids)	0.963	0.021	−1.68	0.093	0.922–1.006	*
Allocare*Mother employed (resids)	0.979	0.021	−1.00	0.357	0.977–1.067	
Constant	0.000	0.000	−7.69	0.000	0.000–0.000	***

***$P < 0.01$; **$P < 0.05$; *$P < 0.1$.

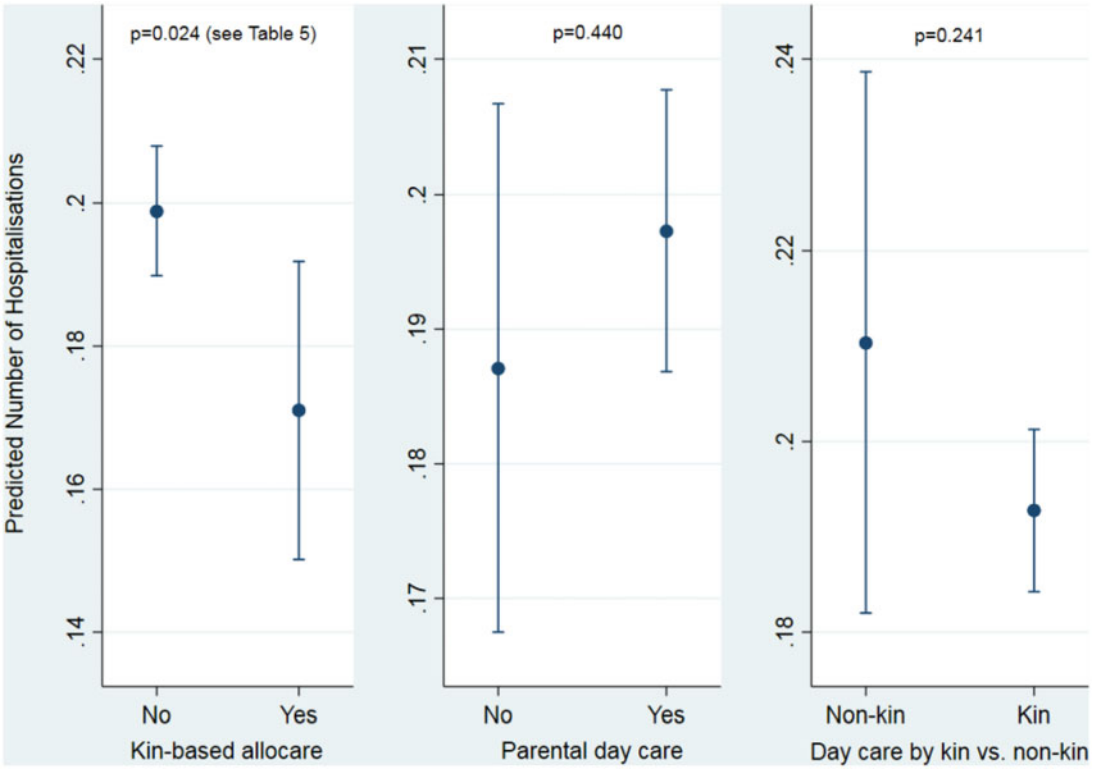

Figure 1. Plots of regression results for the main hypothesis and two alternative kin-selection hypotheses. Estimates of the predicted number of hospitalizations were produced in three separate negative binomial regression analyses including all covariates listed in Table 5. *P* values are for the difference between infant care providers

Sensitivity analysis results

Alloparenting was contrasted with all other care arrangements together in the main statistical model described above and displayed in Table 5. Figure 2 shows alloparenting contrasted with three other forms of care separately, as well as the other sensitivity analysis results. Each point estimate shown in Fig. 2 represents a regression estimate or incidence rate ratio with 95% confidence intervals comparing kin-based allocare with other care arrangements or with different model specifications. Full tables of regression results for these models can be found in The Supplementary Data Appendix. The results showed that kin-based allocare was associated with fewer hospital admissions when contrasted with maternal care, but not with daytime care by non-kin, or with paternal care. Second, the less complex model result did not alter the conclusion that kin-based allocare was associated with number of hospitalizations. Third, including additional variables in the model which plausibly may be associated with infant hospitalization and with kin-based allocare resulted in a slightly larger effect size for kin-based allocare. Fourth, grandparental allocare was included in place of all kin-based allocare to test whether the effect of allocare is likely due to grandparental care alone, rather than any kin-based allocare. The association between grandparental care and hospitalizations was similar to that of kin-based allocare, and was statistically significant. Fifth, tests separating the outcome into hospitalizations for infectious and non-infectious diseases suggested that kin allocare is associated with a reduced risk of infectious disease, but not non-infectious disease. Lastly, on the left side of Fig. 2, analyses are summarized which were carried out using negative binomial regression, and on the right side, as generalized linear models with a log link and gamma distribution. The generalized linear regression modelling approach yielded very similar results to negative binomial regression.

DISCUSSION

Family-based allocare has been demonstrated to reduce child mortality in non-industrialized and in natural fertility societies [9]. The main results of this study suggest that kin-based alloparenting has benefits even under conditions of low infant and child mortality and typical nuclear family living arrangements in WEIRD societies. If the observed effects are part of a wider set of advantages of kin-based allocare, then it is possible that allocare could affect evolutionary fitness in WEIRD societies. However, there is not presently consistent evidence for this, and some studies have shown negative effects of grandparents on child health in WEIRD societies [41, 42].

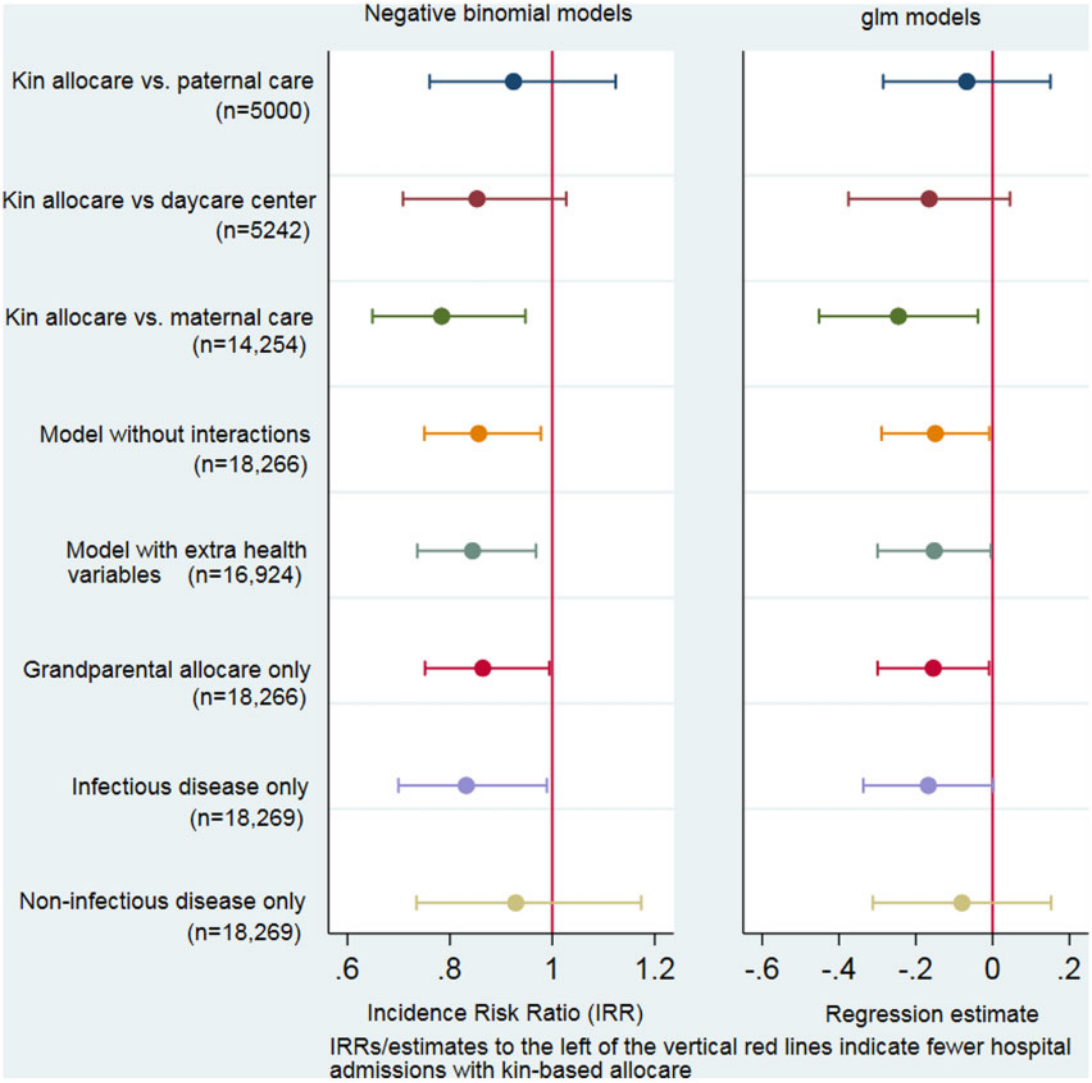

Figure 2. Coefficient plot summarizing sensitivity analysis results predicting number of infant hospitalizations for infants in kin-based allocare using different statistical models and an alternate regression method (glm). Sample sizes are stated for all analyses using subsamples of the MCS. Negative binomial regression estimates are plotted as incidence rate ratios with 95% confidence intervals for kin-based allocare, and glm results are plotted as regression estimates. Full model results for all statistical analyses shown are in the Supplementary Data Appendix

The sensitivity analyses of contrasts between different caregivers showed that kin allocare was most beneficial when compared with mothers alone as main daytime caregivers. This raises the possibility that the finding may be largely driven by constraints on maternal ability to care for an infant by herself. This interpretation is consistent with other studies of allocare which demonstrate that maternal care has substantial time and energy costs which are alleviated by allocare from any individual, biological kin or not [43, 44]. In addition, grandparental daytime infant care was significantly associated with fewer hospital admissions, suggesting that of the categories of kin carers, grandparents were important in their own right.

The causal direction of the association between kin-based allocare and infant hospitalizations cannot be concluded with certainty: it may be the case that mothers tend to care for sickly infants themselves. Reverse causation was addressed through statistical modelling: neonatal health-related variables included in the models produced estimates of kin-based allocare effects mathematically holding neonatal health constant. Kin-based alloparenting was modestly but statistically significantly correlated with covariates which themselves predicted number of infant hospitalization, suggesting that parents were indeed more likely to use allocare when they were in good health, there were no problems in labour and delivery, the baby had a higher birth weight and the family had higher income. A longitudinal study design could address causal direction more conclusively.

There were more infants in kin-based allocare arrangements than in day care with non-kin, suggesting that kin-based allocare remains an important care arrangement in

WEIRD societies [3, 4, 6]. Mothers who had returned to employment within nine months of the birth of the cohort member were much more likely to use kin-allocare (see Table 4). The causal direction of this association may be in both directions: the need to return to employment could drive the need to use kin-based allocare, and having kin allocarers available may facilitate the return to work.

Sensitivity analyses implied that the effects of kin-based allocare were primarily due to reduced exposure to potentially serious infectious diseases. While it is logical that this would be true when compared with children in day-care facilities, it is less clear how infants cared for by their parents would be exposed in ways that infants cared for during the day by grandparents are not exposed. It is possible that the difference is not in exposure to disease, but is instead in susceptibility. In addition, kin-allocarers may indirectly positively affect infant health through transmission of health information to parents [41, 42]. If, for example, grandparents encouraged breastfeeding, this transmission could lead to increased immunity via the protective effects of antigens in breast milk. However, in the MCS grandparental involvement was associated with less breastfeeding by 6 months of age [45, Emmott EH unpublished work].

The present study and the MCS data cannot address exactly which care-related activities provided by kin allocarers were beneficial for infant health. In anthropological studies of non-industrialized societies, allocarers contribute directly to the nutritional status of children [46], but this seems less likely to benefit child health in the MCS. Explanations include the possibility that allocarers, who are usually grandparents, are experienced carers with few competing demands on their time compared to parents and day-care facility staff. This in turn could lead to less exposure of infants to harm and pathogens, as well as to lower stress with its associated growth and immune functioning benefits [47, 48]. A second possibility is that grandparents are less likely to take an infant to the hospital emergency department than a parent. In the MCS, data were not collected on who brought infants to the emergency department, or which hospital admissions were on advice from a paediatrician, general practitioner or help service such as NHS Direct.

Associations between the other covariates and infant hospitalization were consistent with previous studies of risk factors for child health problems [30–35]: boys had more hospitalizations in the first 9 months from birth, and maternal illness and problems during labour and delivery were associated with more hospitalizations. Higher maternal education, father presence in the household, and older ages at birth were associated with fewer hospitalizations.

In conclusion, the results suggested that kin-based allocare is beneficial for infant health relative to other sources of daytime childcare. However, the sensitivity analysis finding that the difference in risk of hospitalization was greatest when comparing infants in kin-based allocare during the day with those of mothers caring for infants alone without any allocare, implies that any help with infant care may be better than none at all. While the results suggest that modest gains in infant health could be made by encouraging and enabling kin-based allocare, labour market trends in the United Kingdom and other WEIRD societies show that since the MCS there has been a shift to more mothers and people in their sixties taking up employment: the supply of potential daytime kin allocarers has been dwindling while the need for allocare is increasing [49].

SUPPLEMENTARY DATA

Supplementary data is available at *EMPH* online.

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DATA SHARING STATEMENT

The data used in this study are available free of charge to researchers via the UK Data Service. The UK Data Service does not allow researchers to deposit data in repositories.

Conflict of interest: None declared.

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