Modelling consultation rates in infancy: influence of maternal and infant characteristics, feeding type and consultation history

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SUMMARY

Background: *Severity of illness, sociodemographic factors, and breastfeeding have been identified as predictors of consultation rates in infants, and prescriptions for antibiotics have been found to increase future consultation rates in older children. The Baby Check trial (1996–1998) provided detailed information about consultations for 935 babies during their first 6 months.*

Aims: *To investigate potential predictors of consultation rates in babies.*

Design of study: *A 6-month cohort study of newborn babies originally enrolled into a randomised controlled trial. Maternal and infant characteristics were collected from hospital discharge records. Primary care consultation data for each baby were collected by case note review.*

Setting: *Thirteen general practices in Glasgow.*

Method: *Multilevel models were used to analyse the number of consultations for each baby during its first 26 weeks, dependent upon the baby's age, the calendar month, maternal and infant characteristics, and previous consultations.*

Results: *The strongest predictors of consultation rates were previous consultations, particularly during the preceding week. Breastfed babies and those with older mothers consulted less often. A multilevel model was better than a fixed effects model, with considerable variation in consultation rates between babies.*

Conclusion: *Infants' consultation rates over time can be analysed using multilevel models, if details of primary care consultations are available. These models can incorporate the effects of fixed variables and those that change during the follow-up period. Our findings add to previous research linking breastfeeding with reduced morbidity in infancy, and for that reason breastfeeding should continue to be promoted in primary care.*

Keywords: *breastfeeding; consultation; infants; primary health care; statistical models.*

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Introduction

THE Baby Check trial was carried out in 1996–1998 to evaluate *Baby Check*, an information booklet designed to assist parents in making the decision about when to consult a doctor for illness in their infant. The trial did not find that the *Baby Check* booklet had an impact on consultation rates,[1] and this was most likely because parents tended not to incorporate information from it into their assessment of infant illnesses.[2] A further goal of the Baby Check trial was to investigate patterns of infant consultation rates. Information was available on all primary care consultations for infants in the first 6 months of life.

Severity of illness is the most powerful predictor of medical consultations in childhood.[3-5] Nevertheless, infant feeding type, antibiotic prescribing history and sociodemographic factors have also been identified as predictors of consult-ation rates.[3,4,6-11] Breastfeeding is associated with better health in infants and children,[9,10,12,13] and in an open randomised trial, Little *et al*[11] found that patients (adults and children aged 4 years and over) were more likely to re-attend with sore throats when antibiotics were prescribed for this condition, suggesting that previous consultation experience may influence subsequent consulting behaviour. Social deprivation is associated with lower breastfeeding rates,[10] higher rates of childhood infection,[14] higher rates of antibiotic prescribing[15] and higher consultation rates in general practice.[4,6,8]

It is likely that the interactions between these factors and infant consultation rates will be complex. In order to clarify these interactions, we present data on consulting patterns from the Baby Check trial.

Method

The mothers of all eligible babies born in 13 Glasgow general practices over a 14-month period from January 1996 were invited to take part in the Baby Check trial.[1] Given the minimal level of intervention involved, ethical approval to use opt-out consent was obtained, and the study population formed 99.3% (997/1004) of those eligible to participate. In this analysis, mothers and babies from both arms of the original trial are analysed, with the study group considered as a covariate in all analyses.

At the time of recruitment, sociodemographic and other infant and maternal characteristics (including feeding method at hospital discharge), taken from maternity hospital discharge forms, were recorded. At the end of follow-up,

HOW THIS FITS IN

What do we know?

Predictors of consultation rates have predominantly been analysed by looking at the total number of consultations for an individual over a fixed period in relation to characteristics at baseline. In this paper we use multilevel models to investigate a variety of potential predictors, which can be measured at baseline or be allowed to change during the follow-up period.

What does this paper add?

We found that the age of a baby, calendar month, feeding method at hospital discharge, maternal age, and consulting history were associated with infant consultation rates. The statistical models used offer a flexible method for analysing such data, whether obtained from observational studies or from randomised trials.

information was gathered on all consultations (except scheduled developmental assessments) for each baby in the trial during the first 6 months of life, including the date of consultation and any prescriptions given.

For each baby, the follow-up period was divided into 26 weeks and the number of consultations during each week was calculated. Two models were fitted and compared; a fixed effects model and a multilevel model, with the number of consultations in any week modelled as a Poisson random variable.

The multilevel model was used to allow for different babies having different tendencies to consult, as well as allowing for different consultation rates across practices. The levels in the model were week of follow-up, baby, and practice.

The fixed effects model accounted for different consultation rates between practices by including a 13-level categorical variable representing the practice that the baby was registered with. The two models were built concurrently, in three stages:

1. Evaluation of the effects of baby's age in weeks (26-level categorical variable) and calendar month (12-level categorical variable).
2. Evaluation of previous consulting history effects by including indicator variables according to whether or not the baby had:
   - Ever had a consultation
   - Had a consultation during the previous week
   - Ever been given a prescription
   - Received a prescription during the previous week
   - Ever been prescribed an oral antibiotic
   - Been prescribed an oral antibiotic during the previous week.
3. Evaluation of potential predictors of consultation rates:
   - Study group (Baby Check or control)
   - Baby's gender
   - Mother's age (included as a linear effect)
   - Mother's parity (first baby or otherwise)
   - Feeding on hospital discharge (breast or bottle)
   - Apgar score (<9 or otherwise)
   - Delivery (vaginal or caesarean section)
   - Gestational age (<36 weeks or otherwise)
   - Birth weight (<2500 g or otherwise)
   - Residential deprivation score (deprivation category 1–2, 3–5 or 6–7).[16,17]

At each stage, the effects of predictor variables were considered under both models, and were eliminated if they were not seen to improve the fit of either model, as assessed by likelihood ratio tests. Throughout, model effect estimates are reported as relative consultation rates (RCR), with 95% confidence intervals (CIs) and *P*-values. No adjustments have been made for multiple comparisons.

To assess goodness-of-fit, each model was used to predict the distribution of the total number of consultations during the 6-month period. Since the probability of having a consultation in any given week was modelled as being dependent upon previous consulting history, a simulation method was used. One thousand simulated studies were generated and the distribution of the total number of consultations averaged across the simulations. The observed and predicted distributions of the total number of consultations were then compared graphically and by means of χ^2-tests, comparing the observed and predicted numbers of babies consulting 0, 1, 2, ... 10 or >10 times during follow-up.

Data were analysed using SPlus for Windows v4.5[18] and MLwiN v1.1.[19]

Ethical approval for this study was granted by the Greater Glasgow Community and Primary Care Research Ethics Committee.

Results

Of the original study population of 997 babies, consultation data for 62 could not be obtained. A further 15 babies were excluded from the analysis, since the date of at least one of their consultations could not be determined. The main dataset contained 920 babies and 2506 consultations.

Table 1 shows the maternal and infant characteristics of the study population and, where comparative data could be obtained, figures relating to the Glasgow and Scottish populations. Forty-two per cent of families lived in relatively deprived areas (deprivation category 6 or 7), and 32% in more affluent areas (deprivation category 1 or 2). Compared with the rest of Glasgow, the study population over-represented the more affluent areas at the expense of areas with intermediate levels of socioeconomic deprivation. The mean maternal age was 29 years, 48% of babies were breastfed at the time of discharge from hospital and 5% were of low birth weight. From Table 1, there is some evidence that the babies studied were less likely to be preterm or of low birth weight, compared with population data. During the study period, 66% of babies received a prescription and 29% received prescriptions for oral antibiotics.

Figure 1 shows the estimated effects of the age of the baby in weeks, and the calendar month under the two models, allowing for different consultation rates across practices. The patterns were similar under the two models. Consultation rates were seen to be low during the first week, rising to their highest levels at 6 weeks, thereafter falling slightly and remaining approximately constant. Over the year, a strong cyclical pattern was seen, with peak consultation rates occurring in winter (February) and the lowest

Table 1. Characteristics of the study population, with local and national comparative data, where available.

Maternal or infant characteristic	Study population: Summary (% [*n*/total])	Study population: Number missing	Comparative data: Glasgow (%)	Comparative data: Scotland (%)	Year
Baby Check	49.9 (459/920)	0	-	-	
Mean age of mothers (years)	28.9[a] (5.4)[b]	47	27.9[a]	28.4[a]	1996[c]
Male infant	52.6 (479/911)	9	51.7	51.5	1996[c]
First-born child	44.4 (399/899)	21	43.9	43.8	1995[c]
Breastfed	48.0 (413/860)	60	48.9	47.4	2000[c]
Apgar score <9	4.8 (40/832)	88	5.9	-	1998[d]
Caesarean delivery	17.7 (155/877)	43	-	16.8	1996[c]
Gestational age <36 weeks	5.2 (40/762)	158	7.2	6.8	1995[c]
Birth weight <2500 g	5.3 (47/889)	31	7.2	5.9	1995[c]
Deprivation category 3–5	25.9 (238/920)	0	44.0	62.0	1999[e]
Deprivation category 6–7	42.3 (389/920)	0	40.7	17.8	1999[e]

[a]Mean age. [b]Standard deviation. Data sources: [c]ISD Scotland website, http://www.isdscotland.org/isd/. [d]Information Services, Greater Glasgow NHS Board. [e]Aggregate data from ISD Scotland.

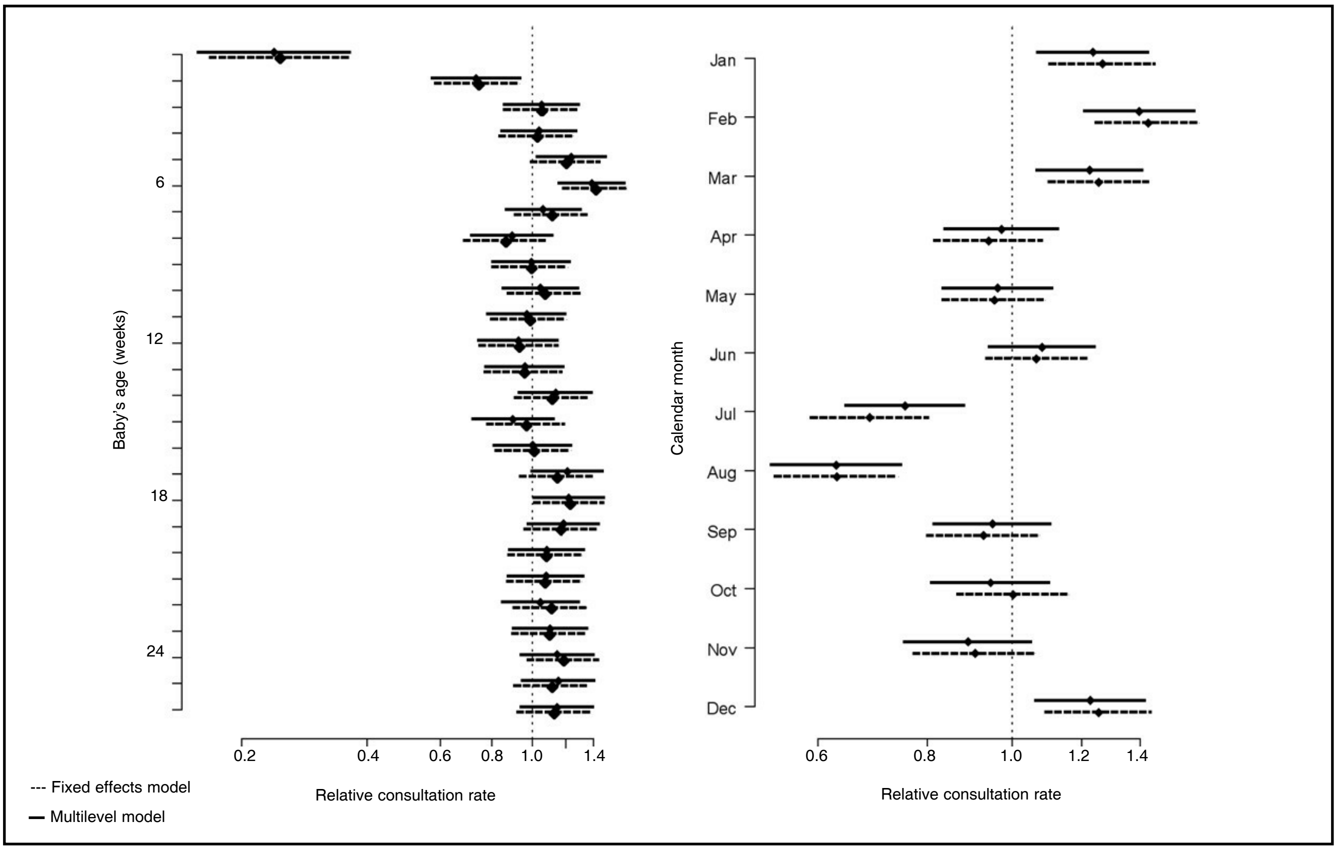

Figure 1. Model predicted consultation rates (relative to mean consultation rate) by week of follow-up (baby's age) and calendar month.

rates in the summer (August). Subsequent models included terms for each month, and terms for each of the first 6 weeks of follow-up, relative to the comparatively steady consultation rate thereafter.

Figure 2 shows the effect estimates for variables relating to previous consulting history and baby characteristics that were included in the final models. These variables were chosen because they significantly improved the fit of at least one of the models. Under the fixed effects model, consultation rates were higher for those who had already had a consultation (RCR = 1.64, 95% CI = 1.47 to 1.83, $P<0.001$), had had a consultation during the previous week (RCR = 2.37, 95% CI = 2.09 to 2.70, $P<0.001$), or had previously been prescribed an oral antibiotic (RCR = 1.24, 95% CI = 1.09 to 1.40, $P<0.001$). Under the multilevel model, the associations between current consultation rate and consulting history were markedly reduced (any previous consultation RCR = 1.21, 95% CI = 1.07 to 1.36, $P = 0.002$; consultation last week RCR = 1.47, 95% CI = 1.28 to 1.69, $P<0.001$), and the association with ever having had an oral antibiotic was no longer apparent (RCR = 1.06, 95% CI = 0.92 to 1.22, $P = 0.43$).

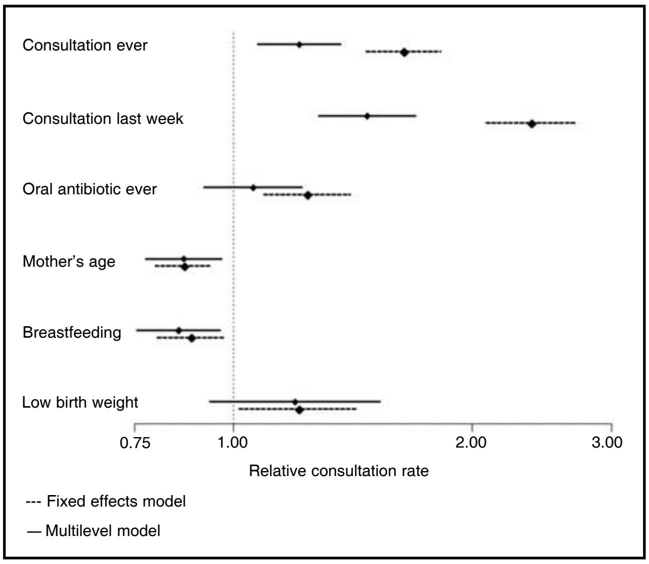

Figure 2: Model estimates of the effects of ever having had a consultation, having had a consultation in the previous week, ever having had an oral antibiotic prescription, mother's age, breastfeeding and birthweight <2500 g.

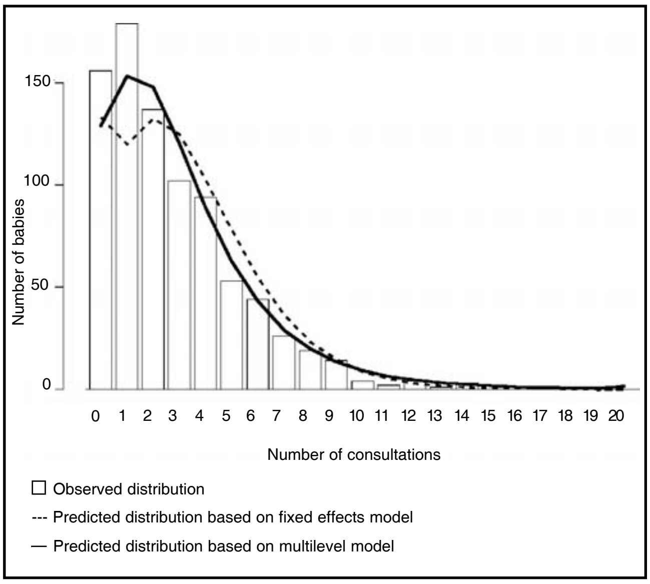

Figure 3. Observed observed and predicted distributions of the total numbers of consultations in this population of babies.

Under the fixed effects model, low birth weight babies were seen to have significantly higher consultation rates than normal weight babies (RCR = 1.21, 95% CI = 1.02 to 1.44, $P = 0.031$), while babies breastfed at the time of discharge from hospital had lower consultation rates than formula-fed babies (RCR = 0.88, 95% CI = 0.80 to 1.44, $P = 0.012$). Older mothers had lower consultation rates than mothers 10 years younger (RCR = 0.87, 95% CI = 0.80 to 0.94, $P<0.001$). Under the multilevel model, effect estimates were virtually unchanged, although the birth weight effect no longer reached formal statistical significance (breastfeeding at the time of discharge from hospital RCR = 0.85, 95% CI = 0.76 to 0.96, $P = 0.009$; maternal age RCR = 0.87, 95% CI = 0.78 to 0.96, $P = 0.009$; low birth weight RCR = 1.20, 95% CI = 0.94 to 1.53, $P = 0.15$).

The multilevel model demonstrated considerable variation in consultation rates between babies, with an estimated variance in log consultation rates of 0.29 ($P<0.001$). This corresponds to a RCR of 3.95 (95% CI = 3.36 to 4.58) between babies at the 90th and 10th percentiles of the consultation rate distribution. Under the fixed effects model, the effect of practice was not seen to improve the fit of the model (F-statistic = 1.44, $P = 0.14$); under the multilevel model, the level 1 random variability was negligible, with a between-practice variance in log consultation rate of 0.0015 ($P = 0.74$).

Figure 3 shows the observed and predicted distributions of the total numbers of consultations in this population of babies. The fixed effects model predicts a bimodal distribution of numbers of consultations, with having exactly one consultation considered less likely than having either no consultations or exactly two. The χ^2 goodness-of-fit statistic for this model was 54.4, $P<0.0001$, indicating a poor model fit. The multilevel model predictions also showed some lack of fit, having a χ^2 statistic of 24.7, $P = 0.016$, although this model clearly offers a better explanation of the data than the fixed effects model.

Both models result in predicted distributions of the number of consultations that are greater than that observed. In the study, the mean number of consultations was 2.75 (95% CI = 2.57 to 2.92), whereas under simulations from the fixed effects model the mean number was 3.19 (95% CI = 3.14 to 3.24) and under simulations from the multilevel model it was 3.12 (95% CI = 3.08 to 3.16).

The lack of fit of both models may be due to the Poisson distribution being inappropriate for the number of consultations during any one week. This mis-specification, although unbiased for the mean number of consultations in any week, conditional on a baby's characteristics and previous consulting history, may overestimate the probability that a baby will have at least one consultation. Under simulations, this overestimation becomes compounded through the influence of consulting history on future consulting rates, resulting in simulated distributions that have mean values greater than that observed.

Discussion

Summary of main findings

We have reported the results of two statistical methods used to examine consulting patterns in infancy, and have demonstrated advantages to using a multilevel, rather than a fixed effects model.

Statistical models

As anticipated, preliminary analyses found that simple Poisson regression of the total number of consultations for each baby over a 6-month period was inadequate and negative binomial regression[20] gave a better description of the Baby Check data. Our aim was to extend these models beyond looking at the effects of maternal and infant characteristics, to examine simultaneously the influence of con-

Commentary

It has long been recognised in sociology[1] and educational research[2] that the behaviour of individuals can be influenced by the groups or hierarchies to which they belong. In other words, the interpretation and analysis of data is not free from the context in which it was obtained. In primary care research, patients' outcomes may depend on patient, general practitioner, and general practice factors. The problem of analysing data that occurs at many levels or groupings comes under the banner of multilevel modelling. Multilevel modelling is an extension of regression analysis that can simultaneously account for factors at more than one level of data. Data in this form arises naturally from cluster randomised trials, in which practices (one level) are randomised rather than individual patients (second level).[3,4] This design may have the advantage of reducing contamination, but the main drawback is the increase in sample size required to show clinically meaningful effects.

It is not immediately obvious, but repeated events or measurements are another form of clustering with two levels, the individual measures (level 1) being clustered within the patient (level 2). McConnachie *et al* use multilevel modelling to assess repeated consultations for babies over a period of time.[5] This approach enabled the consultation rates to vary between individual babies and vary at different times for each baby, rather than the conventional approach of a crude 'average' consultation rate. Thus, multilevel modelling represents an attempt at a more realistic modelling of the structure of datasets and can account for variability at patient and practice levels as well as changes over time, and will increasingly be employed in primary care research.

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sulting history, particularly prescriptions for antibiotics, on subsequent consultation rates.

In the same way that negative binomial regression had been expected to provide a better fit to the total consultation rates than a simple Poisson model, it was expected that a random effects model, allowing for different underlying consultation rates for each baby, would give a better fit than a fixed effects model when the 6-month period was divided into weeks of follow-up. This was confirmed when the multilevel model predicted a total consultation distribution that matched what was observed more closely than the fixed effects Poisson model.

The two models estimated similar covariate effects, with babies of older mothers and breastfed babies consulting less, and low birth weight babies consulting more. However, the models gave different estimates for the effects of previous consultation history. Effect estimates were considerably smaller under the multilevel model, and although having ever had a consultation or having had a consultation during the previous week were still seen to have a significant influence on subsequent consultation rates, having ever had an oral antibiotic prescription had little effect under the multilevel model.

To fit the data, the fixed effects model compensated for the in-built constraint that each baby had an identical underlying consultation rate by placing greater emphasis on previous consulting history, whereby babies who had one consultation would be expected to have more. The resultant predicted distribution of total consultations over 6 months was bimodal, with babies being more likely to consult two or three times or not at all, rather than just once. The multilevel model offers a more realistic explanation of the data by assuming that some babies have higher underlying consultation rates than others. Nevertheless, variables regarding the occurrence of previous consultations were seen to have larger effects than any of the mother and baby characteristics, supporting the view that illness severity is the most important influence on consulting behaviour. An effect of ever having received an oral antibiotic is observed under the fixed effects model but not the multilevel model, implying that the consultation rate distribution underlying the multilevel model includes any effect of antibiotic prescribing if such an effect exists.

Multilevel models have previously been used to model the total number of consultations by individuals over a fixed study period, incorporating random effects at the practice and area levels, assuming that the dependent variable follows a negative binomial distribution.[4] One interpretation of this assumption is that the number of consultations for an individual follows a Poisson distribution, but there is an underlying distribution of consultation rates over the population.[20] By breaking down the observation period and including a random effect for each baby, we are explicitly incorporating this assumption into the model. Furthermore, this approach allows us to analyse consultation rates over time, in terms of both babies' ages and the calendar month, as well as in relation to previous events, such as consulting history. We are not aware of any published work in which multi-level modelling has been used to model consultation rates in this way. Our model fits the observed data well, and the technique appears to have significant value in making sense of this type of data.

Clinical implications

Our study recruited babies from 13 general practices drawing patients from areas with a wide range of socioeconomic conditions. We were able to collect full information on primary care consultations over a 6-month period following birth, from 920 of 997 (92.3%) babies in the Baby Check trial, and were able to examine a range of maternal and infant characteristics that were expected to contribute to consultation rate.

We found that the age of babies, the calendar month, maternal age, feeding mode at hospital discharge, and consulting history were the only significant predictors of infant consultation patterns among the variables available for analysis. Of these, only breastfeeding rates and consulting experience are potentially amenable to intervention by primary care teams.

A consultation is more likely if a baby has already consulted, particularly in the previous week. This phenomenon may be explained by unresolved episodes of illness, by complications of treatment, and by planned reviews by the general practitioners. We are not able to determine the relative magnitudes of these effects from our data.

In an earlier paper, we identified high rates of oral antibiotic prescribing to babies in the first 6 months of life.[1] Respiratory conditions were the most common diagnoses leading to antibiotic prescribing, despite evidence for lack of efficacy.[21-26] In contrast to a previous study of older children,[11] antibiotic prescribing was not found to be a significant predictor of consultation behaviour; in fact we found no evidence that the receipt of any prescription was associated with future consultation rates.

Low socioeconomic status also did not appear to be an independent predictor of infant consultations. It is likely that two factors associated with deprivation, lower maternal age and formula feeding, are major contributors towards the apparent link between deprivation and higher consulting rates found in univariate analyses.[6] Similarly, although women with more than one child tended to consult less often with their babies, this association was not evident in models that controlled for maternal age, suggesting that age is a better marker than parity for 'experience' in this setting.

Increasing breastfeeding rates may be the most effective intervention in primary care to improve infant health and reduce consultation rates. Our data suggest that adjusting for other factors, babies breastfed at the time of discharge from hospital have consultation rates 15% lower than babies fed formula milk. We did not collect data on the duration or exclusivity of breastfeeding. The methods presented here can readily incorporate covariates that change over time, such as breastfeeding status, and could be used to test the hypothesis that exclusive feeding for longer periods increases the beneficial effects of breastfeeding on child health.[12,13]

Our findings add to the existing evidence for the protective effects of breastfeeding on infant health. It is not possible from our data to determine the extent to which breastfeeding is a causal factor or whether additional factors such as maternal 'self-sufficiency' influence both choice of feeding and use of health services. Nevertheless, research using cluster randomised controlled designs[12,13] suggests that there is at least an element of direct causality. Further investigations of interventions to increase breastfeeding rates (for example the UNICEF Baby Friendly initiative[27]) in primary care using cluster randomised trial designs are required to determine the costs and benefits associated with efforts to increase breastfeeding.

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