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Maternal and Perinatal Risk Factors for Infantile Hypertrophic Pyloric Stenosis: A Case- Control Study in Bangladesh

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Abstract

Background: Infantile hypertrophic pyloric stenosis (IHPS) is one of the most common causes of gastric outlet obstruction and non-bilious projectile vomiting in early infancy. Its aetiology is multifactorial, involving genetic, maternal, and perinatal contributions, but locally generated evidence from Bangladesh is limited. This study aimed to identify the sociodemographic, maternal, and perinatal risk factors associated with IHPS among infants presenting to Rajshahi Medical College Hospital (RMCH), Bangladesh.

Methods: A hospital-based case-control study was conducted over one year at RMCH. Data were collection from Janurary1,2026 to June2026 in the Rajshahi Medical College Hospital (RMCH), Bangladesh. Infants aged 0–6 months with suspected IHPS underwent high-resolution Doppler ultrasonography; those with pyloric muscle thickness ≥3 mm were classified as cases (n = 60) and those below this threshold as controls (n = 80). A structured questionnaire captured sociodemographic, maternal, and perinatal factors. Associations were assessed using chi-square or Fisher's exact tests, univariate binary logistic regression, and forward–backward stepwise multivariable logistic regression based on the Akaike Information Criterion.

Results: Bottle-feeding (83.3% of cases vs. 2.5% of controls; crude odds ratio [OR] 195.0, 95% confidence interval [CI] 41.0–927.2), male sex (OR 5.00, 95% CI 2.23–11.22), caesarean delivery (OR 6.43, 95% CI 2.86–14.45), lower socio-economic status (OR 3.16, 95% CI 1.40–7.14), and older maternal age (OR 1.92 per year, 95% CI 1.51–2.46) were significantly associated with IHPS. In the multivariable model, bottle-feeding (adjusted OR 156.8, 95% CI 20.4–1202.4) and maternal age (adjusted OR 1.72 per year, 95% CI 1.29–2.28) remained independent predictors (pseudo-$R^2 = 0.712$; $p < 0.001$).

Conclusions: Bottle-feeding and older maternal age were the strongest independent risk factors for IHPS in this population, consistent with the international literature. Promotion of exclusive breastfeeding and heightened clinical vigilance in infants of older mothers may aid prevention and earlier recognition of IHPS in this setting.

Keywords: Infantile hypertrophic pyloric stenosis; Bottle-feeding; Breastfeeding; Maternal age; Perinatal risk factors; Logistic regression; Bangladesh

Background

Infantile hypertrophic pyloric stenosis (IHPS) is a condition of early infancy characterised by hypertrophy and hyperplasia of the circular muscle layer of the pylorus, producing progressive gastric outlet obstruction. It classically presents between two and eight weeks of life with non-bilious, projectile vomiting, a palpable “olive-shaped” mass in the right upper quadrant, visible peristaltic waves and, if unrecognised, dehydration and hypochloraemic metabolic alkalosis [1, 2]. IHPS affects approximately 1–3 per 1,000 live births in most populations, making it the most common condition requiring abdominal surgery in the first six months of life [1, 3].

The exact aetiology of IHPS remains incompletely understood, but current evidence points to a multifactorial model combining genetic susceptibility with maternal and environmental exposures. Twin and family studies have demonstrated strong heritability [4–6], while population-based cohort and case-control studies have consistently identified male sex, first-born status, caesarean delivery, preterm birth, bottle/formula feeding, maternal smoking, and early postnatal macrolide antibiotic exposure as significant risk factors [7–10]. Bottle-feeding in particular has repeatedly emerged as one of the strongest and most modifiable risk factors, with pooled estimates from meta-analyses showing an approximately two- to two-and-a-half-fold increase in odds compared with breastfeeding [7, 8].

Reported incidence varies considerably by country, era, and ethnicity. Early population-based series from the United Kingdom, Scandinavia, and North America reported incidences of 1.4–4.4 per 1,000 live births with a marked male predominance of 4:1 to 6:1 [11, 12]. From the 1990s onward, several national registries documented a substantial and largely unexplained decline in incidence—for example, from 2.7 to 0.85 per 1,000 in Sweden between 1987 and 1996, and from 4.4 to 1.4 per 1,000 in Scotland between 1981 and 2004—raising the possibility that changing infant-care practices (feeding, sleeping position, and

antibiotic prescribing) contribute to disease occurrence over and above fixed genetic susceptibility [12, 13]. A parallel decline in sudden infant death syndrome (SIDS) led some authors to propose shared secular trends, although a direct causal link has not been established [14]. Administrative data from Germany confirm that the downward trend has continued into the past decade [15], and a multiregional European comparison demonstrated persistent geographic heterogeneity even within countries of similar income level, reinforcing the need for local epidemiological data [16].

A genetic contribution to IHPS is well established. Danish population-based sibling and twin data reported markedly elevated rate ratios among monozygotic twins, dizygotic twins, and siblings of affected infants, with heritability estimated at approximately 87% [4]; reports of concordant IHPS in twins support this familial clustering [6]. Nonetheless, the absence of a single Mendelian inheritance pattern, together with the fluctuating population incidence, indicates that genetic susceptibility is expressed through a threshold model modified by environmental and perinatal exposures.

Among modifiable exposures, infant feeding practice has attracted the most consistent attention. Large cohort and case-control studies have shown that bottle/formula feeding approximately doubles the odds of IHPS relative to breastfeeding, with the effect modified by maternal age and parity—the risk associated with bottle-feeding is disproportionately larger among older, multiparous mothers [17, 18]. A subsequent case-control study corroborated this association while cautioning that a change in feeding method around the time of symptom onset may reflect early, sub-clinical disease (reverse causation) [19]. Proposed biological mechanisms include differences in gastrin release, feeding volume and frequency, and possible irritant effects of formula on the immature pyloric musculature [17, 18].

Other perinatal and maternal exposures implicated in large registry-based studies include male sex, first-born status, caesarean delivery, prematurity, young or (in some populations)

advanced maternal age, and maternal smoking during pregnancy [9, 10, 20, 21]. A large Swedish case-control study spanning three decades found that the relative importance of these factors shifted as background incidence declined, illustrating that risk-factor profiles for IHPS are not necessarily stable over time or transportable without local verification [20]. Socio-economic and educational gradients have also been described, with lower maternal education and disadvantage associated with higher risk in some high-income settings [22]. Postnatal macrolide exposure, particularly erythromycin in the first two weeks of life, is among the best-replicated risk factors, with systematic reviews and a nationwide cohort study reporting two- to three-fold increases in risk [3, 23, 24]; a smaller signal has been reported for azithromycin [25].

Abdominal ultrasonography has progressively replaced contrast studies and clinical palpation as the reference diagnostic standard, with pyloric muscle thickness ≥3 mm and canal length exceeding 14–17 mm the most widely used cut-offs, although some groups have argued that these thresholds may delay diagnosis in very young infants [2, 26, 27]. In Bangladesh, a series from Dhaka Shishu (Children) Hospital demonstrated that ultrasonography combined with clinical findings reliably diagnosed IHPS [28]. Early sonographic diagnosis allows prompt correction of fluid and electrolyte imbalance and definitive pyloromyotomy, for which open and laparoscopic approaches have broadly comparable major-complication rates [29].

Most epidemiological evidence on IHPS risk factors originates from high-income countries with established birth registries; comparable data from South Asia, and Bangladesh specifically, remain scarce [11, 16]. Feeding practices, healthcare-seeking behaviour, and antenatal and perinatal care patterns in Bangladesh differ substantially from those settings. This study therefore aimed to identify the sociodemographic, maternal, and perinatal risk factors associated with IHPS among infants attending Rajshahi Medical College Hospital

(RMCH). Specifically, we sought to compare the characteristics of infants with and without sonographically confirmed IHPS, to quantify crude associations between each candidate risk factor and case status, to identify independent predictors through multivariable logistic regression, and to place the local findings in the context of the international literature.

Methods

Study design and setting

This hospital-based case-control study was conducted over a one-year period, from Janurary1,2026 to June2026, at Rajshahi Medical College Hospital (RMCH), a tertiary referral hospital in Rajshahi, Bangladesh. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for case-control studies.

Participants

Infants were eligible if they were admitted to RMCH with suspected IHPS, were aged 0–6 months, and their parents or legal guardians consented to ultrasonographic examination. Infants whose parents or guardians were unwilling to participate or to provide informed consent were excluded.

Sample size

A minimum sample size of approximately 90 infants was calculated a priori using standard prevalence estimates for IHPS and the statistical power required to detect the anticipated effect sizes. The achieved sample of 140 infants exceeded this minimum.

Sampling

Infants admitted to RMCH who met the inclusion criteria during the study period were enrolled using a purposive sampling approach, aiming for a representative spread of the candidate risk factors under study (e.g., time of delivery, type of delivery, sex, medication

history, and feeding history). Because sampling was non-random, the potential for selection bias is considered in the Discussion.

Data collection

A detailed history was taken for each enrolled infant, including demographic details (age and sex), maternal medical history (hypertension, diabetes, cardiovascular disease, etc.), and maternal lifestyle factors (smoking, alcohol consumption, physical activity, etc.). A pre-designed structured questionnaire was used to assess potential risk factors for IHPS, including time and type of delivery, maternal illness, socio-economic status, maternal smoking and alcohol use, formula feeding, and family history.

All infants underwent abdominal high-resolution Doppler ultrasonography to assess pyloric anatomy, including the length and diameter of the pylorus, pyloric muscle thickness, vascularity of the pyloric muscle and mucosa, and the presence of other lesions.

Case definition

An infant was classified as a case if the sonographically measured pyloric muscle thickness was ≥3 mm, the standard diagnostic threshold for IHPS [2, 26], and as a control if thickness was <3 mm. Applying this criterion yielded 60 cases and 80 controls (N = 140).

Statistical analysis

Categorical variables were summarised as frequencies and percentages and compared between groups using Pearson's chi-square test, or Fisher's exact test where more than 20% of expected cell counts were <5 or any cell count was zero. Continuous variables (maternal age and ultrasound measurements) were summarised as mean ± standard deviation (SD) and compared using the independent-samples t-test. Univariate (crude) binary logistic regression was fitted separately for each candidate risk factor to obtain crude odds ratios (OR) with 95% confidence intervals (CI). A multivariable model was then built using forward–backward stepwise logistic regression, with the Akaike Information Criterion (AIC) as the selection

criterion, to identify independent predictors of case status, yielding adjusted odds ratios (AOR) with 95% CI. All analyses were performed in Python (statsmodels v0.15) with a two-sided significance threshold of $p < 0.05$.

Pyloric muscle thickness, canal length, transverse diameter, Doppler vascularity grade, and the clinical signs of pyloric stenosis (e.g., visible peristalsis, projectile vomiting, and an olive sign) are the diagnostic criteria used to define or confirm a case and were therefore, by design, present almost exclusively in the case group. These variables are reported descriptively but were excluded from the logistic regression analyses, since entering a variable that deterministically defines the outcome produces complete separation. The regression analyses therefore focus on the candidate sociodemographic, maternal, and perinatal risk factors.

Where a 2×2 comparison contained a zero cell (quasi-complete or complete separation) in the univariate analysis (e.g., maternal occupation, maternal illness, and absent post-natal care), the Haldane–Anscombe correction (adding 0.5 to every cell) was applied to obtain a finite OR and CI. These estimates are flagged in the corresponding table, and such variables were excluded from the multivariable model because standard maximum-likelihood estimation cannot be performed on them.

Results

Participant characteristics

A total of 140 infants aged 0–6 months met the inclusion criteria over the one-year study period, of whom 60 (42.9%) were classified as cases and 80 (57.1%) as controls. Their sociodemographic and clinical characteristics are presented in Table 1 and Fig. 1. Male infants accounted for 83.3% of cases and 50.0% of controls, and 83.3% of cases were bottle-fed compared with 2.5% of controls. Mothers of cases were older than mothers of controls (30.3 ± 1.17 vs. 24.68 ± 4.51 years; $t = 9.428$, $p < 0.001$; Fig. 2).

Ultrasonographic findings

As expected given the case definition, sonographic pyloric measurements differed markedly and consistently between groups (Table 2, Fig. 2), confirming the validity of the case/control classification. All controls had grade I Doppler vascularity, whereas cases had grade II (n = 50) or grade III (n = 10) vascularity.

Bivariate associations

Nearly all candidate sociodemographic and perinatal variables showed a statistically significant bivariate association with case status, with the exception of parity and infant age group at presentation (Table 3).

Figure 3 shows Cramér's V, a measure of association strength (0 = no association; 1 = perfect association), between every pair of categorical variables, including case/control status. This highlights risk factors that move together (e.g., maternal occupation and maternal illness were both very strongly linked to case status and to each other) and helped identify collinear variables before multivariable modelling. Figure 4 shows the proportion of infants who were cases within each category of each variable, sorted from lowest to highest risk.

Univariate logistic regression

Crude odds ratios for all candidate risk factors are presented in Table 4 and Fig. 5. Bottle-feeding (OR 195.0, 95% CI 41.01–927.2), caesarean delivery (OR 6.43, 95% CI 2.86–14.45), male sex (OR 5.00, 95% CI 2.23–11.22), lower socio-economic status (OR 3.16, 95% CI 1.40–7.14), and maternal age (OR 1.92 per year, 95% CI 1.51–2.46) were significantly associated with case status. Clinic delivery (OR 0.28) and rural compared with village residence (OR 0.25) were associated with lower odds of IHPS.

Multivariable logistic regression

Candidate variables considered for the stepwise procedure were sex, socio-economic status, maternal education (collapsed), residence (village vs. rural/urban), mode of delivery, place of

delivery, post-natal care, dietary habits, and maternal age (continuous). Maternal occupation and maternal illness were excluded a priori because they showed complete separation from case status, and maternal hypertension medication was excluded because it is collinear with (a subset of) maternal illness. Bottle-feeding (AOR 156.8, 95% CI 20.44–1202.4) and maternal age (AOR 1.72 per year, 95% CI 1.29–2.28) were retained in the final model as independent predictors (Table 5, Fig. 6).

Discussion

This hospital-based case-control study set out to identify sociodemographic, maternal, and perinatal risk factors for IHPS among infants presenting to RMCH. Bottle-feeding and older maternal age emerged as the two strongest, mutually independent predictors of case status on multivariable analysis, while male sex, caesarean delivery, lower socio-economic status, lower maternal education, hospital (versus clinic) delivery, and absent post-natal care were significant at the bivariate level.

The finding that bottle/formula feeding carried markedly elevated odds of IHPS is consistent with, though numerically larger than, pooled estimates from international meta-analyses, which report odds or risk ratios of roughly 1.7 to 2.5 for bottle-feeding compared with breastfeeding [7, 8, 17]. Krogh et al., in a large Danish cohort, similarly found a substantially elevated risk among bottle-fed infants, particularly among older and multiparous mothers—an effect-modification pattern that resonates with the co-occurrence of bottle-feeding and older maternal age in the present sample [17]. Proposed mechanisms include irritant or hypertrophic effects of formula on the pyloric musculature and differences in feeding volume, frequency, and gastrin release between bottle- and breastfed infants [18]. The much larger effect size in this cohort likely reflects the small proportion of bottle-fed controls (2.5%) in a setting where breastfeeding is the near-universal norm; a behaviour that is rare in the population appears especially discriminating.

Older maternal age remained an independent predictor after adjustment, and mothers of cases were on average five to six years older than mothers of controls. This mirrors the interaction reported by Krogh et al., in which the bottle-feeding effect was most pronounced among mothers aged 35 years and above [17], and is broadly consistent with registry data associating IHPS with maternal and pregnancy characteristics [20]. The association may reflect cumulative exposure to reproductive or metabolic risk factors, or confounding by feeding choices that vary with maternal age in this population.

The five-fold higher odds of IHPS among male infants is consistent with the well-established male predominance reported internationally (pooled risk ratios of roughly 2.7 to 5, depending on the population) [9, 30]. Similarly, the association with caesarean delivery echoes large Scandinavian and meta-analytic studies linking caesarean section, first-born status, and preterm birth with IHPS, although the biological mechanism remains speculative and may partly reflect residual confounding by indication or by unmeasured factors such as gestational diabetes [9, 10, 30].

Lower socio-economic status and lower maternal education were both significantly associated with case status. Comparable gradients by maternal education and ethnicity have been reported in high-income settings [22], although the mechanism is not established and may operate indirectly through feeding practices (e.g., earlier or more frequent recourse to formula), antenatal care utilisation, or environmental exposures not fully captured by our questionnaire.

Several variables (maternal illness, maternal occupation, and absence of post-natal care) showed complete or near-complete separation from control status, meaning virtually no controls fell into the exposed category. Although the continuity-corrected odds ratios for these variables were very large and statistically significant, their extremely wide confidence

intervals indicate that the estimates are fragile and should be interpreted as hypothesis-generating rather than confirmatory.

The literature also implicates postnatal macrolide exposure (particularly erythromycin in the first two weeks of life) and a strong familial component in IHPS aetiology [3, 4, 23–25]. Although the questionnaire captured family history and maternal medication history, macrolide exposure was not separately analysed in the present dataset and represents an important variable for future data collection.

Taken together, these findings support a multifactorial model of IHPS in which a largely non-modifiable genetic and male-sex predisposition interacts with modifiable perinatal exposures, chief among them infant feeding practice. From a public-health perspective, the strength of the bottle-feeding association reinforces the value of exclusive breastfeeding promotion, which may plausibly contribute to a lower background incidence of IHPS in addition to its other well-established benefits for mothers and infants.

Strengths and limitations

A strength of this study is that every participant underwent standardised high-resolution Doppler ultrasonography, providing an objective, uniformly applied case definition. To our knowledge, it is also among the few studies to examine maternal and perinatal risk factors for IHPS in Bangladesh. Several limitations should nevertheless be considered. First, the single-centre, hospital-based design means that the findings may not generalise to community-level incidence or to populations with different feeding norms and healthcare-seeking behaviour. Second, cases and controls were enrolled purposively rather than randomly, which may introduce selection bias; the very large effect sizes observed for some variables (e.g., bottle-feeding and maternal illness) should be interpreted with this possibility in mind. Third, exposures such as feeding history, delivery details, and maternal illness were ascertained by interview and are subject to recall and reporting bias, as in most IHPS case-control studies.

Fourth, several candidate risk factors (maternal occupation, maternal illness, post-natal care, and maternal antihypertensive medication) showed zero or near-zero exposure among controls, producing unstable odds ratios with very wide confidence intervals. Fifth, maternal smoking, alcohol consumption, and postnatal macrolide exposure—established risk factors internationally [3, 21, 23–25]—were part of the planned questionnaire but were not available as analysable variables. Sixth, although the achieved sample exceeded the planned minimum, the number of cases (n = 60) limited the number of predictors that could reliably be entered into the multivariable model. Finally, as a case-control study, this work can quantify association but not causation; reverse causation is implausible for most exposures studied, but residual confounding cannot be excluded.

Conclusions

In this hospital-based case-control study in Bangladesh, bottle-feeding and older maternal age were strong, independent risk factors for IHPS, while male sex, caesarean delivery, lower socio-economic status, and lower maternal education were significant at the bivariate level. These findings are consistent with the international literature and support a multifactorial aetiological model combining genetic predisposition with modifiable perinatal exposures. Strengthening exclusive breastfeeding counselling, particularly for older mothers and those of lower socio-economic status, and maintaining a high index of suspicion for IHPS in male infants, infants born by caesarean section, and infants of older mothers presenting with non-bilious projectile vomiting may aid prevention and earlier diagnosis. Larger, multi-centre prospective studies using random or consecutive sampling, and capturing maternal smoking, alcohol use, and early-life macrolide exposure, are needed to validate these associations.

Abbreviations

AIC: Akaike Information Criterion

AOR: Adjusted odds ratio

CI: Confidence interval

IHPS: Infantile hypertrophic pyloric stenosis

IQR: Interquartile range

NVD: Normal vaginal delivery

OR: Odds ratio

RMCH: Rajshahi Medical College Hospital

SD: Standard deviation

SIDS: Sudden infant death syndrome

STROBE: Strengthening the Reporting of Observational Studies in Epidemiology

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from IBSC University of Rajshahi. Written informed consent was obtained from the parents or legal guardians of all participating infants prior to enrolment.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

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Clinical trial number

Not applicable.

Authors' contributions

AKMAK: conceptualisation, data collection, investigation, writing – original draft. MAH: conceptualisation, supervision, methodology, writing – review and editing. MAW: methodology, supervision, writing – review and editing. MMR: formal analysis, visualisation, writing – review and editing. All authors read and approved the final manuscript.

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Figure titles and legends

Fig. 1 Distribution of key sociodemographic and perinatal factors in cases and controls

Bars show the percentage of infants within each group (case, n = 60; control, n = 80) falling into each category of gender, dietary habits, mode of delivery, socio-economic status, place

of delivery, mother's education, residence, and mother's occupation. NVD, normal vaginal delivery.

Fig. 2 Maternal age and pyloric ultrasound measurements by group

Box plots with individual data points for mother's age (years), pyloric muscle thickness (mm), pyloric canal length (mm), and transverse diameter (mm) in cases and controls. Boxes show the median and interquartile range (IQR); whiskers show the range.

Fig. 3 Strength of association between case status and risk factors (Cramér's V)

Heat map of Cramér's V between case/control status and all sociodemographic and perinatal risk factors (0 = no association; 1 = perfect association). SES, socio-economic status; HTN Meds, maternal antihypertensive medication.

Fig. 4 Case rate within each risk-factor category

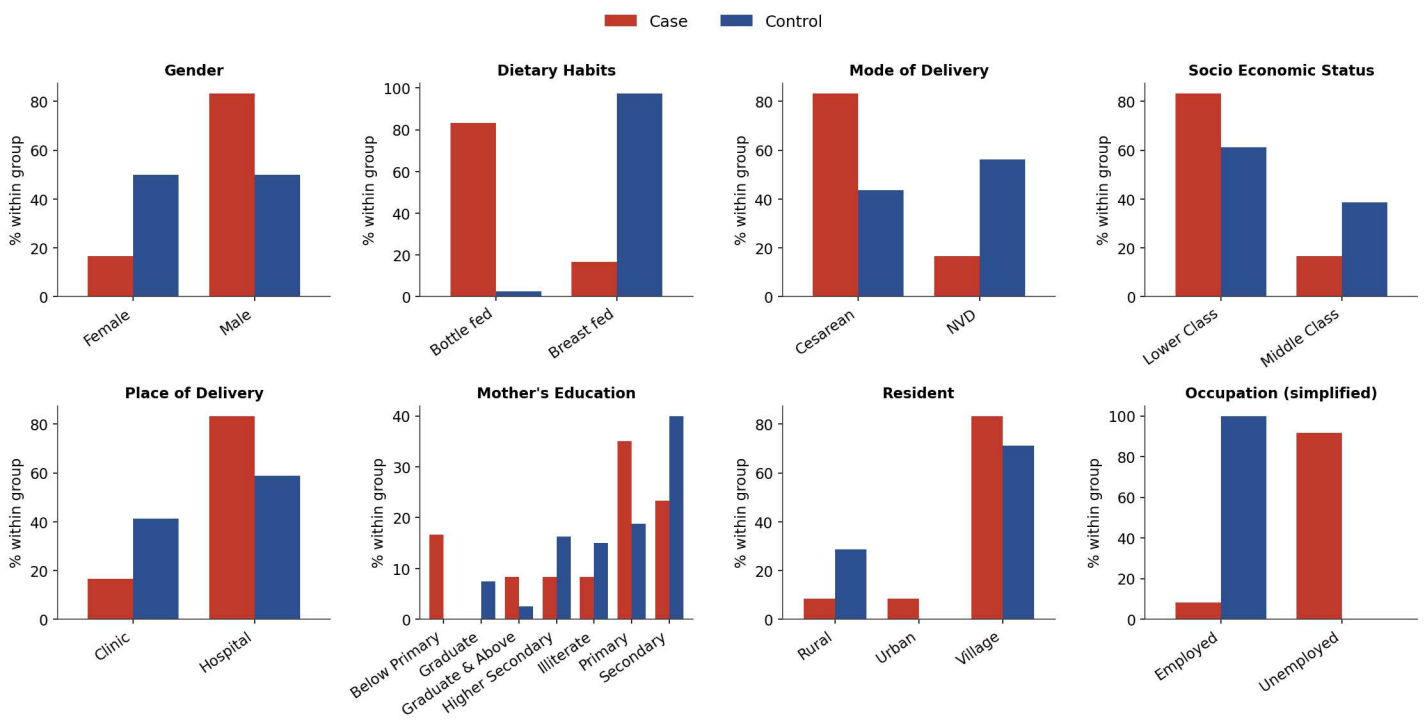
Heat map of the percentage of infants who were cases within each category of each risk factor, sorted from lowest (green) to highest (red) risk.

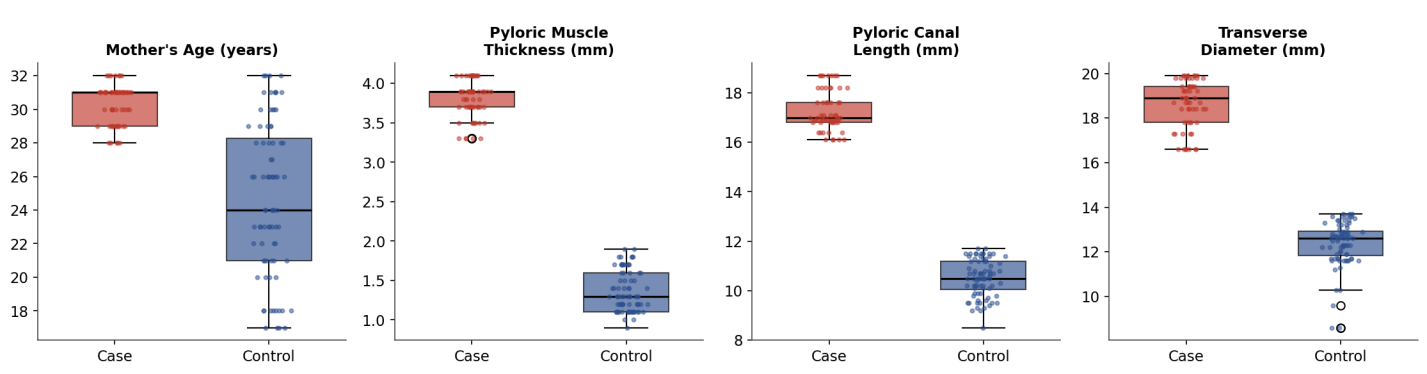
Fig. 5 Crude odds ratios for candidate risk factors

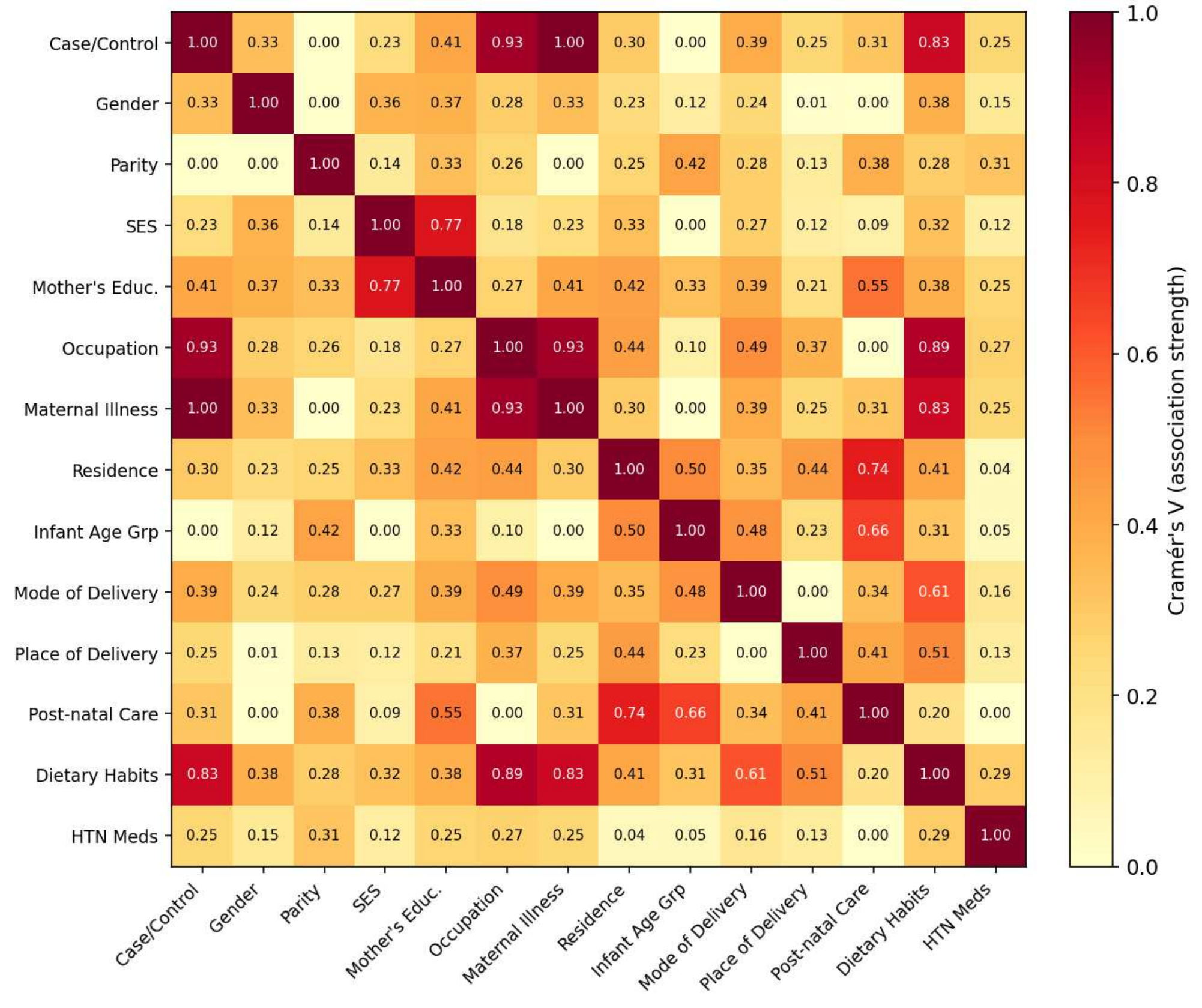
Forest plot of crude (univariate) odds ratios with 95% confidence intervals on a log scale. Red, statistically significant ($p < 0.05$); grey, not significant. Confidence intervals exceeding 1000 are truncated for display only.

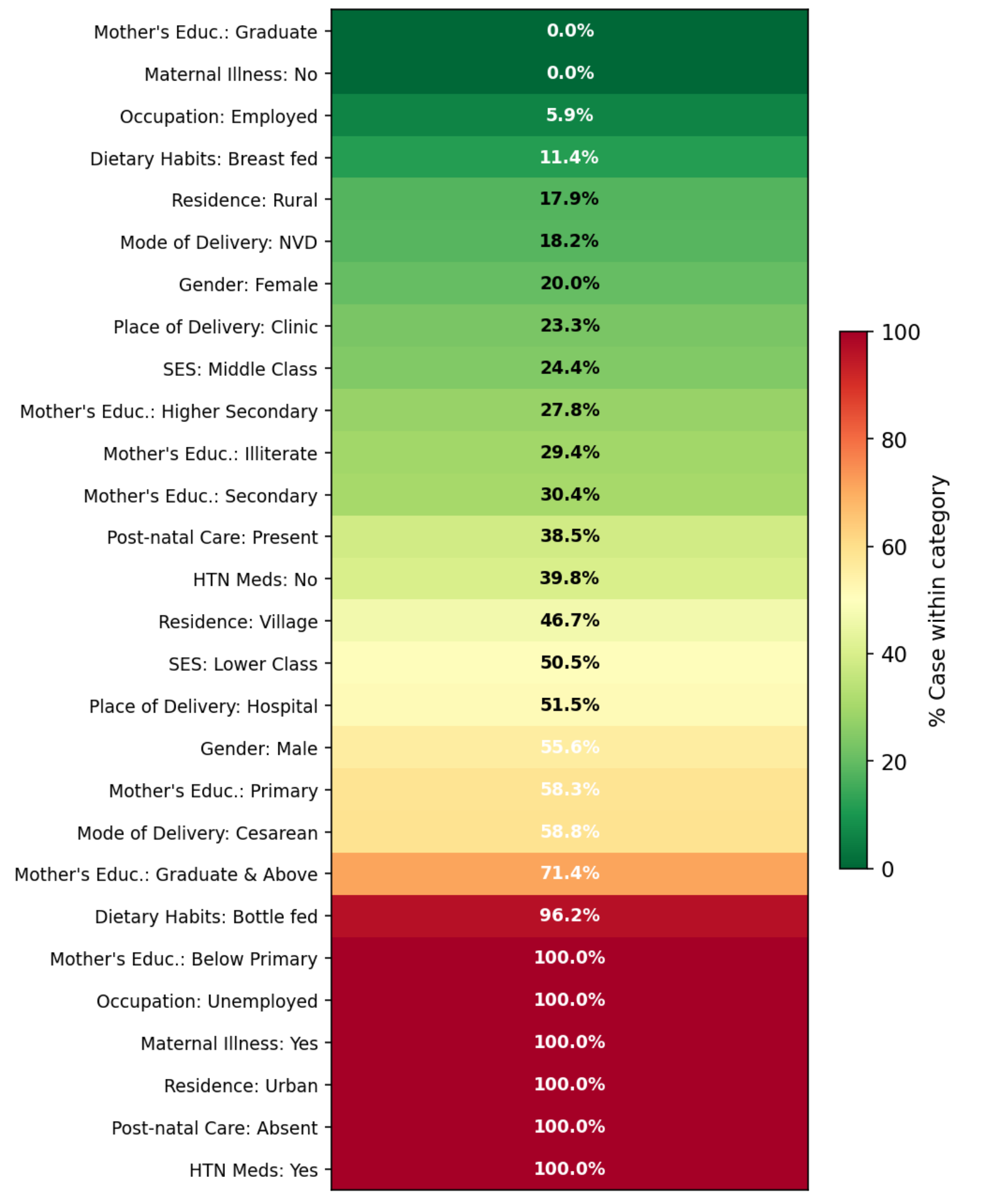
Fig. 6 Adjusted odds ratios from the final multivariable model

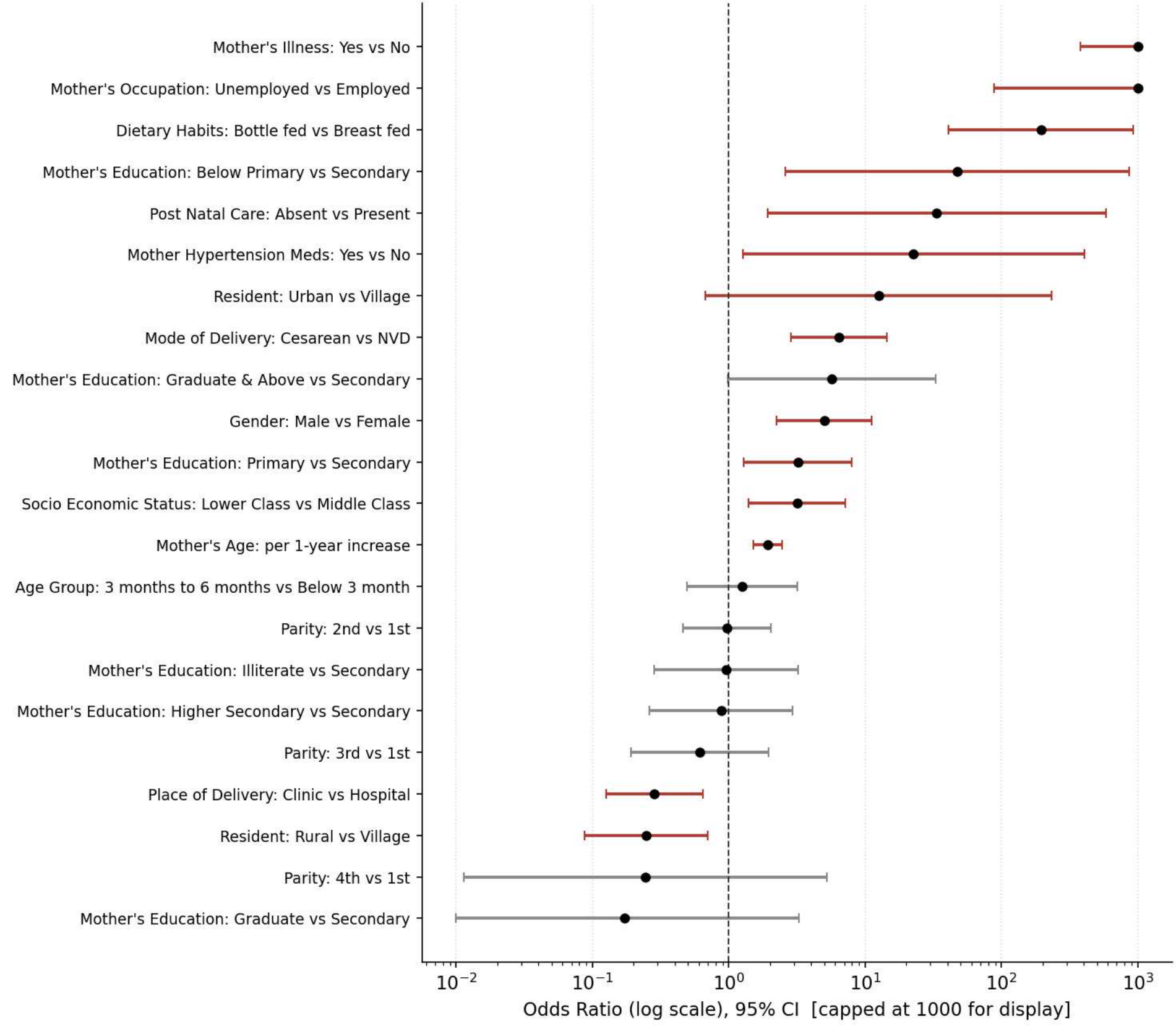
Adjusted odds ratios (log scale) with 95% confidence intervals for the two variables retained in the final stepwise multivariable logistic regression model: bottle-feeding and mother's age (per 1-year increase).


Case
Control
Gender
% within group
Female
Male
Dietary Habits
Bottle fed
Breast fed
Mode of Delivery
Cesarean
NVD
Socio Economic Status
Lower Class
Middle Class
Place of Delivery
Clinic
Hospital
Mother's Education
Below Primary
Graduate
Graduate & Above
Higher Secondary
Illiterate
Primary
Secondary
Resident
Rural
Urban
Village
Occupation (simplified)
Employed
Unemployed


Mother's Age (years)
32
30
28
26
24
22
20
18
Case
Control
Pyloric Muscle Thickness (mm)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Case
Control
Pyloric Canal Length (mm)
18
16
14
12
10
8
Case
Control
Transverse Diameter (mm)
20
18
16
14
12
10
Case
Control


Case/Control 1.00 0.33 0.00 0.23 0.41 0.93 1.00 0.30 0.00 0.39 0.25 0.31 0.83 0.25
Gender 0.33 1.00 0.00 0.36 0.37 0.28 0.33 0.23 0.12 0.24 0.01 0.00 0.38 0.15
Parity 0.00 0.00 1.00 0.14 0.33 0.26 0.00 0.25 0.42 0.28 0.13 0.38 0.28 0.31
SES 0.23 0.36 0.14 1.00 0.77 0.18 0.23 0.33 0.00 0.27 0.12 0.09 0.32 0.12
Mother's Educ. 0.41 0.37 0.33 0.77 1.00 0.27 0.41 0.42 0.33 0.39 0.21 0.55 0.38 0.25
Occupation 0.93 0.28 0.26 0.18 0.27 1.00 0.93 0.44 0.10 0.49 0.37 0.00 0.89 0.27
Maternal Illness 1.00 0.33 0.00 0.23 0.41 0.93 1.00 0.30 0.00 0.39 0.25 0.31 0.83 0.25
Residence 0.30 0.23 0.25 0.33 0.42 0.44 0.30 1.00 0.50 0.35 0.44 0.74 0.41 0.04
Infant Age Grp 0.00 0.12 0.42 0.00 0.33 0.10 0.00 0.50 1.00 0.48 0.23 0.66 0.31 0.05
Mode of Delivery 0.39 0.24 0.28 0.27 0.39 0.49 0.39 0.35 0.48 1.00 0.00 0.34 0.61 0.16
Place of Delivery 0.25 0.01 0.13 0.12 0.21 0.37 0.25 0.44 0.23 0.00 1.00 0.41 0.51 0.13
Post-natal Care 0.31 0.00 0.38 0.09 0.55 0.00 0.31 0.74 0.66 0.34 0.41 1.00 0.20 0.00
Dietary Habits 0.83 0.38 0.28 0.32 0.38 0.89 0.83 0.41 0.31 0.61 0.51 0.20 1.00 0.29
HTN Meds 0.25 0.15 0.31 0.12 0.25 0.27 0.25 0.04 0.05 0.16 0.13 0.00 0.29 1.00
Case/Control
Gender
Parity
SES
Mother's Educ.
Occupation
Maternal Illness
Residence
Infant Age Grp
Mode of Delivery
Place of Delivery
Post-natal Care
Dietary Habits
HTN Meds
1.0
0.8
0.6
0.4
0.2
0.0
Cramér's V (association strength)


Mother's Educ.: Graduate
0.0%
Maternal Illness: No
0.0%
Occupation: Employed
5.9%
Dietary Habits: Breast fed
11.4%
Residence: Rural
17.9%
Mode of Delivery: NVD
18.2%
Gender: Female
20.0%
Place of Delivery: Clinic
23.3%
SES: Middle Class
24.4%
Mother's Educ.: Higher Secondary
27.8%
Mother's Educ.: Illiterate
29.4%
Mother's Educ.: Secondary
30.4%
Post-natal Care: Present
38.5%
HTN Meds: No
39.8%
Residence: Village
46.7%
SES: Lower Class
50.5%
Place of Delivery: Hospital
51.5%
Gender: Male
55.6%
Mother's Educ.: Primary
58.3%
Mode of Delivery: Cesarean
58.8%
Mother's Educ.: Graduate & Above
71.4%
Dietary Habits: Bottle fed
96.2%
Mother's Educ.: Below Primary
100.0%
Occupation: Unemployed
100.0%
Maternal Illness: Yes
100.0%
Residence: Urban
100.0%
Post-natal Care: Absent
100.0%
HTN Meds: Yes
100.0%
100
80
60
40
20
0
% Case within category


Mother's Illness: Yes vs No
Mother's Occupation: Unemployed vs Employed
Dietary Habits: Bottle fed vs Breast fed
Mother's Education: Below Primary vs Secondary
Post Natal Care: Absent vs Present
Mother Hypertension Meds: Yes vs No
Resident: Urban vs Village
Mode of Delivery: Cesarean vs NVD
Mother's Education: Graduate & Above vs Secondary
Gender: Male vs Female
Mother's Education: Primary vs Secondary
Socio Economic Status: Lower Class vs Middle Class
Mother's Age: per 1-year increase
Age Group: 3 months to 6 months vs Below 3 month
Parity: 2nd vs 1st
Mother's Education: Illiterate vs Secondary
Mother's Education: Higher Secondary vs Secondary
Parity: 3rd vs 1st
Place of Delivery: Clinic vs Hospital
Resident: Rural vs Village
Parity: 4th vs 1st
Mother's Education: Graduate vs Secondary
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Odds Ratio (log scale), 95% CI [capped at 1000 for display]

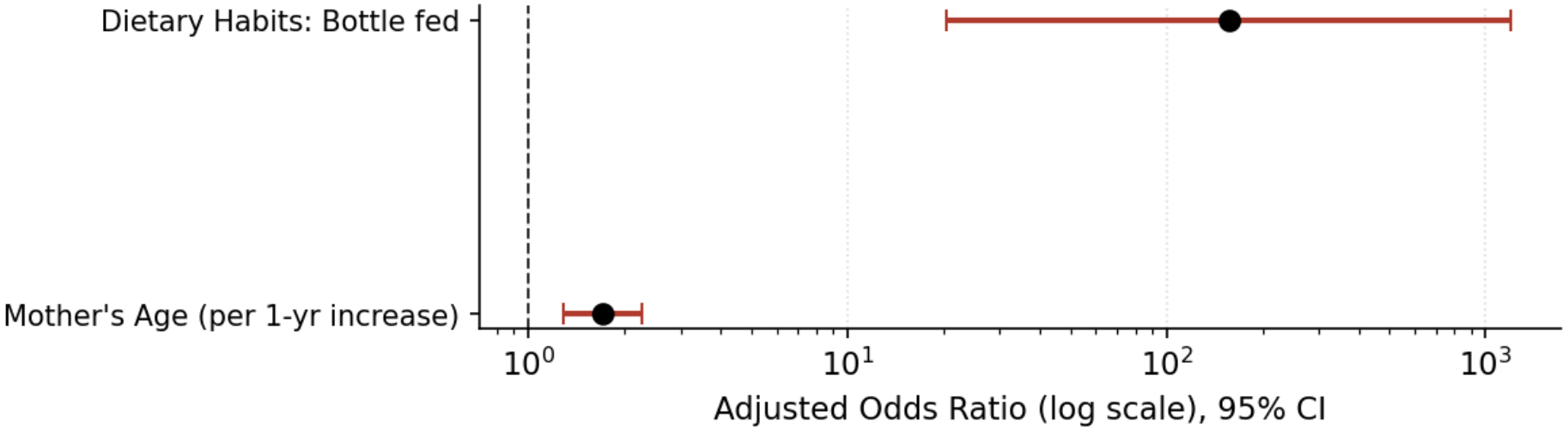

Dietary Habits: Bottle fed
Mother's Age (per 1-yr increase)
10^0
10^1
10^2
10^3
Adjusted Odds Ratio (log scale), 95% CI

Table 1 Sociodemographic and clinical characteristics of cases and controls

Variable	Category	Case (n = 60), n (%)	Control (n = 80), n (%)
Gender	Female	10 (16.7)	40 (50.0)
	Male	50 (83.3)	40 (50.0)
Parity	1st	36 (60.0)	44 (55.0)
	2nd	19 (31.7)	24 (30.0)
	3rd	5 (8.3)	10 (12.5)
	4th	0 (0.0)	2 (2.5)
Mother's education	Illiterate	5 (8.3)	12 (15.0)
	Below primary	10 (16.7)	0 (0.0)
	Primary	21 (35.0)	15 (18.8)
	Secondary	14 (23.3)	32 (40.0)
	Higher secondary	5 (8.3)	13 (16.2)
	Graduate	0 (0.0)	6 (7.5)
	Graduate and above	5 (8.3)	2 (2.5)
Socio-economic status	Lower class	50 (83.3)	49 (61.2)
	Middle class	10 (16.7)	31 (38.8)
Mother's occupation	Employed	5 (8.3)	80 (100.0)
	Unemployed	55 (91.7)	0 (0.0)
Mother's illness (diabetes or hypertension)	No	0 (0.0)	80 (100.0)
	Yes	60 (100.0)	0 (0.0)
Residence	Village	50 (83.3)	57 (71.2)
	Rural	5 (8.3)	23 (28.8)
	Urban	5 (8.3)	0 (0.0)
Infant age group	Below 3 months	50 (83.3)	69 (86.2)
	3 to 6 months	10 (16.7)	11 (13.8)
Mode of delivery	Caesarean	50 (83.3)	35 (43.8)
	NVD	10 (16.7)	45 (56.2)
Place of delivery	Hospital	50 (83.3)	47 (58.8)
	Clinic	10 (16.7)	33 (41.2)
Post-natal care	Present	50 (83.3)	80 (100.0)
	Absent	10 (16.7)	0 (0.0)
Dietary habits	Bottle-fed	50 (83.3)	2 (2.5)
	Breastfed	10 (16.7)	78 (97.5)
Maternal antihypertensive medication	No	53 (88.3)	80 (100.0)

Variable	Category	Case (n = 60), n (%)	Control (n = 80), n (%)
	Yes	7 (11.7)	0 (0.0)
Mother's age (years)	Mean ± SD	30.3 ± 1.17	24.68 ± 4.51

Mother's occupation was collapsed to employed/unemployed and mother's illness to no/yes (diabetes or hypertension) for analysis. Independent-samples t-test for mother's age: t = 9.428, p < 0.001. NVD, normal vaginal delivery; SD, standard deviation.

Table 2 Ultrasonographic pyloric measurements and Doppler vascularity grade by group

Measurement	Case (n = 60)	Control (n = 80)	t	p-value
Pyloric muscle thickness (mm), mean ± SD	3.80 ± 0.24	1.36 ± 0.26	56.851	<0.001*
Pyloric canal length (mm), mean ± SD	17.25 ± 0.77	10.51 ± 0.74	52.242	<0.001*
Transverse diameter (mm), mean ± SD	18.64 ± 1.08	12.37 ± 1.02	35.182	<0.001*
Doppler vascularity grade, n				
Grade I	0	80		
Grade II	50	0		
Grade III	10	0		

*p < 0.05. These measurements are diagnostic criteria for IHPS and were not entered into the logistic regression models. SD, standard deviation.

Table 3 Bivariate association between candidate risk factors and case status

Variable	Test	χ^2 / t statistic	df	p-value
Gender	Chi-square	15.172	1	<0.001*
Parity	Chi-square	2.237	3	0.525
Infant age group	Chi-square	0.057	1	0.811
Socio-economic status	Chi-square	7.043	1	0.008*
Mother's education	Chi-square	29.512	6	<0.001*
Mother's occupation (simplified)	Chi-square	116.972	1	<0.001*
Mother's illness (any)	Chi-square	135.946	1	<0.001*
Residence	Chi-square	14.467	2	<0.001*
Mode of delivery	Chi-square	20.893	1	<0.001*
Place of delivery	Chi-square	8.616	1	0.003*
Post-natal care	Fisher's exact	—	—	<0.001*
Dietary habits	Chi-square	92.523	1	<0.001*
Maternal antihypertensive medication	Fisher's exact	—	—	0.002*

Variable	Test	χ^2 / t statistic	df	p-value
Mother's age (years)	Independent t-test	9.428	138	<0.001*

*p < 0.05. Fisher's exact test was used where expected cell counts were <5. df, degrees of freedom.

Table 4 Univariate (crude) binary logistic regression of candidate risk factors for IHPS

Variable	Category (vs. reference)	Crude OR	95% CI	p-value
Gender	Male vs. female	5.00	2.23–11.22	<0.001*
Parity	2nd vs. 1st	0.97	0.46–2.04	0.931
	3rd vs. 1st	0.61	0.19–1.95	0.406
	4th vs. 1st	0.24	0.01–5.24	0.501
Infant age group	3–6 months vs. below 3 months	1.25	0.49–3.18	0.633
Socio-economic status	Lower vs. middle class	3.16	1.40–7.14	0.006*
Mother's education	Primary vs. secondary	3.20	1.28–7.97	0.013*
	Higher secondary vs. secondary	0.88	0.26–2.94	0.834
	Illiterate vs. secondary	0.95	0.28–3.22	0.937
	Graduate and above vs. secondary	5.71	0.99–33.08	0.052
	Graduate vs. secondary	0.17	0.01–3.27	0.174
	Below primary vs. secondary	47.07	2.58–858.7	<0.001*
Mother's occupation	Unemployed vs. employed†	1624.6	88.04–29979.7	<0.001*
Mother's illness	Yes vs. no†	19481.0	381.1–995853.5	<0.001*
Residence	Rural vs. village	0.25	0.09–0.70	0.008*
	Urban vs. village	12.52	0.68–232.2	0.026*
Mode of delivery	Caesarean vs. NVD	6.43	2.86–14.45	<0.001*
Place of delivery	Clinic vs. hospital	0.28	0.13–0.64	0.002*
Post-natal care	Absent vs. present†	33.48	1.92–583.8	<0.001*
Dietary habits	Bottle-fed vs. breastfed	195.0	41.01–927.2	<0.001*
Maternal antihypertensive medication	Yes vs. no†	22.57	1.26–403.5	0.002*

Variable	Category (vs. reference)	Crude OR	95% CI	p-value
Mother's age (years)	Per 1-year increase	1.92	1.51–2.46	<0.001 *

*p < 0.05. †Zero cell present in the 2×2 table; OR computed with the Haldane–Anscombe correction (0.5 added to every cell). Confidence intervals for these estimates are wide and should be interpreted cautiously. CI, confidence interval; NVD, normal vaginal delivery; OR, odds ratio.

Table 5 Final stepwise multivariable logistic regression model for IHPS

Variable retained in final model	Adjusted OR	95% CI	p-value
Dietary habits: bottle-fed (vs. breastfed)	156.8	20.44–1202.4	0.001*
Mother's age (per 1-year increase)	1.72	1.29–2.28	0.001*

*p < 0.05. Model summary: n = 140; constant = −17.258; log-likelihood = −27.537; AIC = 61.07; pseudo-R^2 = 0.712; likelihood-ratio test vs. null model p < 0.001. AIC, Akaike Information Criterion; CI, confidence interval; OR, odds ratio.