Journal of Midwifery & Reproductive Health

JMRH.mums.ac.ir

The Association between Household Food Insecurity and Preterm Birth: A population-based Case-Control Study using electronic records

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ARTICLE INFO

Article type:
Original article

Article History:
Received: 13-Jan-2024
Accepted: 15-Mar-2024

Key words:
Preterm Birth
Pregnancy Outcome
Case-control Study
Food Insecurity

ABSTRACT

Background & aim: Preterm birth is a leading cause of infant morbidity and mortality worldwide. Previous studies have linked household food insecurity to preterm birth and adverse maternal health outcomes, but population-based evidence is limited. This study examines the association between household food security and preterm birth among mothers in Mashhad, Iran.

Methods: A case-control study using electronic health records from the SINA healthcare database at Mashhad University of Medical Sciences was conducted. The study included 2,431 mothers with preterm births and an equal number of mothers with term deliveries, selected through random sampling (March 2019–March 2022). Food security over the past 12 months was assessed using a validated household questionnaire. Logistic regression analyses determined associations between food insecurity and preterm birth.

Results: Mothers from food-insecure households had three times higher adjusted odds of preterm birth (AOR 3.10; 95% CI 2.37-4.05, $p < 0.001$) compared to mothers from food-secure households. Other significant risk factors included preeclampsia (AOR 1.97; 95% CI 1.22-3.18, $p = 0.005$), gestational diabetes (AOR 5.95; 95% CI 3.03-11.68, $p < 0.001$), and low birth weight (AOR 47.27; 95% CI 35.01-63.82, $p < 0.001$).

Conclusion: Household food insecurity was strongly associated with an increased risk of preterm birth, even after adjusting for medical and social factors. Improving food security during pregnancy could reduce preterm birth rates and improve maternal and neonatal health outcomes.

► *Please cite this paper as*:
Khodadadi N, Amiri Z, Neshat Iranpour M, Nourozi M, Bavafa Valenlia Kh, Moradi A, Latifnejad Roudsari R, Mosa Farkhani E. The Association between Household Food Insecurity and Preterm Birth: A population-based Case-Control Study using electronic records. Journal of Midwifery and Reproductive Health. 2025; 13(2): 4775-4784. DOI: 10.22038/JMRH.2024.77466.2298

Introduction

It is essential to ensure that every child is given a strong foundation in life, as the benefits of a positive start can have long-lasting impacts. It is imperative to note that developmental anomalies can enhance the likelihood of encountering physical health challenges during an individual's life (1-2). Assessing preterm birth and low birth weight are key factors in evaluating newborns and determining survival rates across different countries (3). Premature birth is characterized by the early delivery of a

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baby before 37 weeks of gestation or less than 259 days from the onset of the mother's last menstrual period (4). Research indicates that the premature birth rate is 9.6%, with variations observed in different urban areas. The continents of Asia and Africa exhibit the highest incidence of preterm births, making up approximately 85% of reported cases. The combined effect of these regions results in a 3a.1% contribution to the overall worldwide burden of disease. In Iran, the prevalence of this illness varies from 5.6% to 34.9%, while in the United States, it is estimated to range between 12% and 13%. Unfortunately, the specific coordinates are not provided (5- 6).

The elevated occurrence of preterm birth in impoverished areas has been substantiated by studies, which highlight the contribution of both psychological and biological factors. Research suggests that a variety of factors can contribute to preterm birth. Ensuring sufficient food availability is vital for providing a healthy and active life for everyone. Food security serves as a fundamental pillar in promoting good health and nutrition. The nutritional well-being of children is primarily influenced by factors such as finances, economics, and family dynamics, which directly impact their access to adequate food (7), thus primarily influencing food security. Food insecurity encompasses three levels: mild, moderate, and severe. This predicament is both complex and dynamic, as it can give rise to malnutrition, persistent hunger, short-term growth impediments, overconsumption, and subsequent weight gain and obesity. Consequently, it may be associated with the dual burden of malnutrition (8-9). Food and Agriculture Organization (FAO) research reveals a concerning trend of food insecurity, which has affected a staggering 2 billion individuals globally. Within this number, approximately 8% of the population in North America and Europe experienced difficulties in accessing a reliable supply of safe, nutritious, and adequate food during the year 2018 (10). Expectant mothers, considered a vulnerable group, are more prone to suffering from numerous adverse health consequences (11).

Numerous persistent conditions, such as stunted growth, obesity, diabetes, and cardiovascular diseases (13), have been associated with food insecurity. Nevertheless, there is a lack of substantial evidence regarding the correlation between food insecurity and adverse pregnancy outcomes, including miscarriage, premature delivery, and low birth weight (12). Females have a greater level of food insecurity in comparison to males, mainly as a result of gender imbalance (13). Techniques like specific prenatal care and education on prenatal and postpartum nutrition could be employed to minimize the occurrence of low birth weight. To successfully achieve the goals of reducing infant mortality as stated in the 2030 Sustainable Development Goals (SDGs), it is crucial to gather significant information about the occurrence of low birth weight and its related factors. This data will assist in the formulation of prompt interventions (14-15).The increased preterm births in economically disadvantaged regions may be ascribed to a confluence of psychological and biological factors. Researchers assert that preterm birth is a complex disorder influenced by several factors. Furthermore, investigations have brought attention to the correlation between food insecurity and adverse pregnancy outcomes, particularly influencing maternal health by elevating the chances of gestational diabetes, hypertension, and excessive weight gain. Furthermore, research findings on food insecurity and adverse pregnancy outcomes have emphasized their impact on maternal health conditions such as gestational diabetes, hypertension, and obesity (16). Limited research exists regarding the correlation between food poverty and newborn outcomes, specifically preterm delivery. Due to the contradictory results of the research, the notable and prevalent presence of this result in pregnancy, and the continuous uncertainty among researchers regarding the origin of its significance concerning social, economic, medical, and psychological factors, it could potentially stem from any of these variables individually. This research examines the association between food security and preterm birth among mothers residing in Mashhad, Iran (1-17).

Materials and Methods

The design was a population-based case-control utilized secondary data from the Sina Electronic Health Record (SinaEHR) system, a comprehensive health information system developed and implemented by MUMS. SinaEHR supports primary care delivery across various regions of Iran, serving over 5 million people (18-19). It captures standardized clinical data, including diagnoses coded using the International Classification of Diseases, 10th Edition (ICD-10), and integrates laboratory results through a laboratory information system, facilitating real-time clinical decision-making. Pregnant women receiving routine antenatal care at healthcare centers affiliated with Mashhad University of Medical Sciences ، Mashhad, Iran were included in this study. Data were obtained from the Sina electronic health record system (SINAEHR), covering the period from March 1, 2019, to March 20, 2022, for mothers delivering at hospitals in Mashhad, Iran. Cases comprised 2,431 mothers with preterm singleton births (<37 weeks' gestation), matched with an equal number of mothers with full-term deliveries (≥37 weeks' gestation) as controls. Exclusion criteria encompassed mothers with newborns having congenital or genetic anomalies, a maternal history of drug or alcohol abuse, and anemia during the index pregnancy.

The exposure variable was household food security status over the 12 months preceding delivery, categorized as secure food or insecure food using a validated survey tool. The outcome variable was preterm birth (<37 weeks gestation). Confounding variables included sociodemographic factors, obstetric factors, and clinical factors.

Household food security: Categorized as either food secure or food insecure based on the validated survey tool and labeled as secure and insecure.

Preterm birth: Preterm birth is a live birth that occurs before 37 completed weeks of pregnancy.

Obstetric factors: Obstetric factors are pregnancy-related conditions or complications affecting maternal and neonatal outcomes, such as preeclampsia, gestational age, and type of delivery.

Clinical factors: Clinical factors refer to medical conditions, patient characteristics, and physiological indicators that influence health outcomes, diagnosis, treatment, or disease progression such as Diabetes mellitus and Chronic hypertension.

The Persian validated version of this scale was used in the SinaEHR database. In the validation process conducted by Moosavian et al., Mohammadi et al. confirmed the questionnaire's internal reliability and validity, with a Cronbach's α of 0.855.

Household food security status was assessed using the Household Food Insecurity Access Scale, developed by the United States Agency for International Development to address the multifaceted nature of food security(20). A validated questionnaire adapted from the USDA module, which was validated for use in Iranian households, was used to assess household food security status. The Persian-validated version of this scale was employed in the SinaEHR database. During the validation process conducted by Mousavian et al., Mohammadi et al. confirmed its internal reliability and validity, reporting a Cronbach's α of 0.855. The scale consists of nine items assessing food insecurity over the past four weeks, with responses rated on a two-point scale (Yes = 1, No = 0). Each item is followed by a frequency query on a three-point scale ('Rarely,' 'Sometimes,' or 'Often'), scored from 1 to 3, respectively. If the main response is "No," the frequency question is skipped (21-22).

The case and control groups each comprised 2,431 individuals. Case group selected through a census method. For each case included in the study, one control was included in the study by simple randomization method.

Following data collection, the information underwent coding and was subsequently inputted into Excel. It was then transferred into Stata version 16 for analysis purposes. Frequencies and percentages were computed to outline the categorical participant characteristics, obstetric history, and food security status disparities between preterm cases and term controls. Bivariate analysis consisting of chi-square and t-tests were initially conducted to assess unadjusted relationships between each factor and preterm birth. Variables demonstrating a trend towards association with preterm birth ($P<0.05$) were considered candidate parameters for inclusion in a multivariate logistic regression model. The final model estimated adjusted odds ratios (AOR) and 95% confidence intervals representing the independent relationships between food insecurity and preterm birth after controlling for relevant sociodemographic, clinical, and obstetric confounders. An alpha level of 0.05 determined statistical significance in the regression analysis. Statistical analysis was carried out using Stata software version 16.

Results

The study included 2,431 cases of mothers with preterm birth and 2,431 controls. The sociodemographic characteristics of the study population are summarized in Table 1.

Table 1. The Sociodemographic characteristics of women with preterm birth

Variables	Cases N (%)	Controls N (%)	P-Value
Maternal age, mean (SD), years	31.71(7.10)	34.13(6.32)	<0.001[b]
Educational Level			
Elementary and less	520(21.39)	435(17.89)	0.002[c]
Diploma and more	1996(82.11)	1911(78.61)	
Maternal job			
Housewife	1757(72.27)	1767(72.69)	0.74[c]
Employee	674(27.73)	664(27.31)	
History of Cigarette Smoking			
No	2265(98.48)	2244(98.38)	0.78[c]
Yes	35(1.52)	37(1.62)	
Inactive smoking			
No	1698(96.59)	1909(96.66)	0.90[c]
Yes	60(3.41)	66(3.34)	
Body Mass Index mean (SD), (kg/m^2)	26.69(5.47)	27.32(5.18)	<0.001[b]
mean (SD),(week) Age Gestational	33.10(2.35)	37.23(2.25)	<0.001[b]
History of Stillbirth			
No	1509(97.29)	2122(98.84)	0.001[c]
Yes	42(2.71)	25(1.16)	
Preeclampsia			
No	2007(91.90)	2214(97.75)	<0.001[c]
Yes	177(8.10)	51(2.25)	
Type Of Delivery			
Natural birth	1440(65.07)	1152(50.37)	<0.001[c]
Cesarean section	773(34.93)	1135(49.63)	
Food security			
Secure	2029(83.46)	2,244(92.31)	<0.001[c]
Insecure	402(16.54)	187(7.69)	
Sex			
Female	1171(48.17)	1178(48.46)	0.84[c]
Male	1260(51.83)	1253(51.54)	
Diabetes mellitus			
No	2256(97.54)	2290(99.26)	<0.001[c]
Yes	57(2.46)	17(0.74)	
Chronic hypertension			
No	2273(98.31)	2295(99.31)	0.002[c]
Yes	39(1.69)	16(0.69)	
Birth weight			
Normal	909(37.39)	2359(97.04)	<0.001[c]
Low birth weight	1522(62.61)	72(2.96)	

a All data are presented as mean ± SD or N (%); b Independent T test; Chi-square test

The mean maternal age among cases of preterm birth was 31.71 years (±7.10), significantly lower than that of the control group (34.13 years ± 6.32) (P<0.001). A higher proportion of mothers with preterm birth had a Diploma or higher (82.11%) compared to the control group (78.61%) (P= 0.002). There were no significant differences in maternal job status between the two groups (P=0.74) Both groups showed minimal differences in the history of cigarette smoking (P=0.78) and exposure to inactive smoking (P=0.90). However, a significantly higher proportion of mothers with preterm birth had a lower mean BMI (26.69 kg/m^2) compared to controls (27.32 kg/m^2) (P<0.001). Mothers with preterm birth had a significantly lower mean gestational age (33.10 weeks) compared to controls (37.23 weeks) (P<0.001). Additionally, a higher proportion of mothers with preterm birth reported a history of stillbirth (2.71% vs. 1.16%) (P=0.001) and preeclampsia (8.10% vs. 2.25%) (P<0.001) compared to controls. Cesarean section was more prevalent in the control group (49.63%) compared to the case group (34.93%) (P<0.001). A significantly higher proportion of mothers with preterm birth experienced food insecurity (16.54%) compared to controls (7.69%) (P<0.001). Mothers with preterm birth had significantly higher rates of diabetes (2.46% vs. 0.74%) (P<0.001) and chronic blood pressure (1.69% vs. 0.69%) (P=0.002) compared to controls. Furthermore, a significantly higher proportion of preterm births were classified as low birth weight (62.61%) compared to controls (2.96%) (P<0.001). These findings elucidate the sociodemographic disparities and clinical characteristics associated with preterm birth, emphasizing the multifactorial nature of this condition.

Univariate analyses detected significant unadjusted associations between preterm birth and several variables with P-value <0.20, which were selected as candidate parameters for inclusion in a multivariate logistic regression model. After adjustment in the multivariate analysis, several factors retained their significant associations with preterm birth.

Table2. Univariate and multivariable analyses to assess factors associated with preterm birthVariables

	Univariate COR (95%CI)	P-Value	Multivariate AOR (95%CI)	P-Value
Food security				
Insecure	2.37(1.97-2.85)	<0.001	3.10(2.37-4.05)	<0.001
Secure	Ref		Ref	
Maternal age	0.94(.93 -. 95)	<0.001	0.97(.95-.98)	<0.001
Educational level				
Diploma and more	1.24(1.08-1.43)	0.002	0.91(.73-1.14)	0.44
Elementary and less	Ref		Ref	
History of stillbirth				
Yes	2.36(1.43- 3.89)	0.001	1.34(.66-2.71)	0.40
No	Ref		Ref	
Birth weight				
Normal	Ref		Ref	
Low birth weight	54.85(42.78-70.3)	<0.001	47.27(35.01-63.82)	<0.001
Preeclampsia				
Yes	3.82(2.78 -5.25)	<0.001	1.97(1.22-3.18)	0.005
No	Ref		Ref	
Body Mass Index	0.97(.96 -.98)	<0.001	1.01(.99-1.03)	0.06
Chronic hypertension				
Yes	2.46(1.37-4.41)	0.003	1.53 (.695-3.58)	0.32
No	Ref		Ref	
Gestational Diabetes				
Yes	3.40(1.97 -5.86)	<0.001	5.95 (3.03-11.68)	<0.001
No	Ref		Ref	

All data are presented as Odds Ratio (OR) with 95% Confidence Interval.

Importantly, preeclampsia, education level, birth weight, history of stillbirth, food security status, maternal age, gestational diabetes, chronic blood pressure, and BMI (all variables with p-values < 0.05). Furthermore, no evidence of multicollinearity was found between predictors in the multivariate model, ensuring the robustness of the findings. There was a significant association between the lack of food security in households and the odds of giving birth prematurely. Mothers living in households with food insecurity demonstrated notably increased chances of having preterm birth in contrast to those in food-secure households, as indicated by both the bivariate (COR 2.37, P<0.001) and multivariate analyses (AOR 3.10, P<0.001). This suggests that food insecurity may independently contribute to an increased risk of preterm birth among mothers in the study population, even after accounting for potential confounding variables. maternal age was identified as protection against preterm birth, as older mothers exhibited reduced chances of encountering preterm birth in contrast to younger mothers. This inverse association between maternal age and preterm birth was consistently observed in both the bivariate (COR 0.94, P<0.001) and multivariate analyses (AOR 0.97, P<0.001), highlighting the importance of considering maternal age in assessing the risk of preterm birth. However, education level did not show a significant association with preterm birth in the multivariate analysis. Despite the slightly increased odds of preterm birth among mothers with a diploma or higher education level observed in the bivariate analysis (COR 1.24, P=0.002), this effect was not statistically significant after adjusting for other variables (Table 2).

Discussion

The findings of this case-control study, conducted among approximately 4862 mothers in Mashhad, Iran, revealed that mothers facing food insecurity had three times higher chances of giving birth prematurely compared to those who had food security. This association persisted after adjusting for socioeconomic, clinical, and obstetric variables. Food insecurity has been associated with a multitude of adverse health effects in diverse contexts and through various mechanisms, regardless of one's socioeconomic status. However, there has been a lack of thorough investigation into the relationship between food insecurity and preterm birth (23-24).

A recent study of 674 healthy pregnant women in urban Iran reported a twofold increase in the odds of preterm birth among mothers from food-insecure households Likewise, a cohort investigation in urban South Africa identified a distinct correlation between food insecurity and gestational age Another study in the USA found an association between food insecurity and preterm birth among parous women (25-27).

In this study, no association was found between the mother's job and the preterm birth, and it was not included in the multivariate analysis, while in other studies Maternal employment was a protective factor for both preterm birth (28). While Saurel-Cubizolles et al (29) and Agbla et al reported that Maternal job was a risk factor for preterm birth (30).

The added burdens of pregnancy may exacerbate food access issues for vulnerable women (25, 31). These factors, including heightened maternal stress and depression, can increase the risks of preterm delivery (32-34). There is also evidence that chronic inflammation, which is linked to food deprivation, may trigger early labor (35-36). Food insecurity often results in poor maternal nutrition, which directly elevates risks of adverse birth outcomes (37). The added nutritional demands during pregnancy may further tax limited food availability within financially constrained households. Compounding this problem, the physical discomforts of late pregnancy and interruptions for frequent medical visits may necessitate stopping work, potentially reducing critical income (26). Aligning with prior research, our study discovered an 85% increase in the probability of preterm birth among mothers diagnosed with preeclampsia when compared to those without this complication. These findings align with Davies et al (38), who identified a notable link between preeclampsia and preterm birth in their cross-sectional study. Similarly, Koike et al. (39) observed that the repeated risk of preterm birth is attributable to preeclampsia. This condition, marked by elevated blood pressure and proteinuria, poses a threat to both the mother and the developing fetus, leading to long-term cardiovascular risks. Furthermore, pre-existing diabetes substantially raised the risks, showing more than a 5-fold higher likelihood compared to mothers without diabetes, echoing similar results from previous studies (32). Ray et al. (40) examined the outcomes of patients with pregestational diabetes and gestational diabetes mellitus (GDM) in the DEPOSIT study and found a higher risk of preterm birth in pregnant women with preexisting diabetes. However, this increased risk was attributed to maternal adiposity rather than diabetes itself. Furthermore, the study did not distinguish between spontaneous and iatrogenic preterm births when counting the total number of preterm births. The DEPOSIT study revealed a strong correlation between adiposity (weight gain during pregnancy) and the risk of preterm birth. Additionally, BMI appears to be relevant to the risk of preterm birth only in primipara (41).

Prior evidence links lower maternal education attainment with increased risks of adverse birth outcomes like preterm delivery and low birth weight (35-37, 42). Within our study group, although not achieving statistical significance, there was a tendency for mothers with a high school education or higher to exhibit a 9% decrease in adjusted odds of preterm birth when compared to mothers with lower levels of education Our study despite the non-significance of body mass index with preterm birth and the lack of association, our study was different from previous studies for nulliparous women, obesity may provide one marker for who may be at higher risk of PTB and suggests that more research is warranted to inform care management interventions for this high-risk group (43-45). In initial descriptive analyses, we found that the population of pregnant women who experience food insecurity had significantly less education, than women from fully food secure households. These findings are consistent with findings for the general population(46). No significant correlation was observed between preterm birth and the level of education among women, which aligns with the findings of the longitudinal study conducted by Dolatian (47).

The strengths of this study include its large sample size, population-based design, and the incorporation of a comprehensive set of potential confounding variables in the analysis. Nonetheless, several limitations should be noted:

- This study relied on retrospective data from a regional tertiary care center, which may limit the generalizability of the findings to the broader population.
- Food security status was assessed through a survey reflecting the prior 12 months, which did not allow for capturing potential fluctuations during pregnancy.
- While the analysis adjusted for several confounders, residual or unmeasured confounding cannot be ruled out (e.g., individual-level stress, inflammation markers).
- The case-control design demonstrates association but cannot confer causality between food access and preterm birth.
- Micronutrient deficiencies were not assessed and may represent an operative mechanism needing further investigation.

Conclusion

This study provides valuable insights into the epidemiology of preterm birth, highlighting actionable targets for preventive strategies and intervention programs aimed at reducing the burden of preterm birth and improving maternal and neonatal health outcomes. Specifically, the findings reveal a significant association between household food insecurity and a threefold higher likelihood of preterm birth, even after adjusting for various socio-demographic, clinical, and obstetric factors. Integrating nutritional assessment and support within prenatal care could significantly impact this leading cause of infant mortality and morbidity. Moreover, a comprehensive approach that considers both the health and social needs of low-income mothers and children offers a sustainable prevention model. Future research should include longitudinal assessments of food access throughout pregnancy and investigate potential synergistic risks with inflammation pathways. Urgent public health action is needed to implement locally informed interventions aimed at improving food security among vulnerable women of reproductive age, both regionally and globally.

Declarations

Acknowledgments

Many thanks to Mashhad State Health Center for allowing us to carry out this project.

Conflicts of interest

The authors declared no conflicts of interest.

Ethical Considerations

Privacy was maintained for all collected data, and informed consent was obtained from all participants. Furthermore, study outcomes were communicated to the participants

Code of Ethics

This research obtained ethical approval from the Research Ethics Committee at Mashhad University of Medical Sciences (IR.MUMS.FHMPM.REC.1402.191).

Funding

Financial support was done by Mashhad University of Medical Sciences, Mashhad, Iran with ethical code 4020929.

Authors' contribution

NKH and EM contributed to the conception, drafting the manuscript and language editing of the manuscript. ZA contributed to the conception, data collection and Drafting the manuscript. MN and MS and AM contributed to the conception, datamcollection, statistical analyses and interpretation of data. All authors read and approved the final manuscript and agreed to be accountable for all aspects of the work.

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