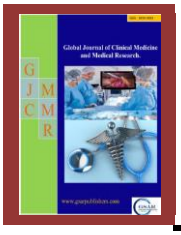

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A Community-Based Survey on Maternal Nutritional Patterns and Epigenetic Risk Indicators for Childhood Non-Communicable Diseases (NCDs): A Clinical Pharmacist Perspective

By

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Abstract

Background: *Prenatal nutrition is vital in fetal programming and epigenetic alteration, hence determining future non-communicable diseases (NCDs) risk in childhood. Poor maternal nutrition, lack of adherence to micronutrient supplements, and improper use of medications during pregnancy are some of the significant issues in terms of public health in developing countries.*

Aim and objective: *The study evaluated the maternal nutritional status, the presence of micronutrient supplements, medication exposure, and epigenetic risk proxy indicators of childhood NCDs and investigated the preventive potential of clinical pharmacists based on community-based data.*

Methodology: *The community-based retrospective cross-sectional survey involved 210 postnatal mothers who were administered with a structured and pre-validated questionnaire. Epigenetic proxy risk factors were maternal diets, adherence to supplements, exposure to medication, and early childhood outcomes (low birth weight, preterm birth, and exclusive breastfeeding). Inferential and descriptive statistical analysis was conducted.*

Results: *The maternal nutrition in the course of pregnancy was found poor in 57.6% of the participants. The adherence rate was reported to be 49.5% and 44.3% with regular adherence to iron-folic acid and calcium supplementation. The prevalence was low birth weight (23.8%), preterm birth (18.6) and insufficient exclusive breastfeeding (41.9%). Low nutritional scores and non-adherence to supplements were of a significant correlation with negative early-life outcomes.*

Conclusion: *There was a significant association between adverse epigenetic risk proxy indicators and suboptimal maternal nutrition and poor supplement adherence. Enhancing community-based, pharmacist-led, nutritional counselling can help in decreasing the risk of intergenerational NCD.*

Keywords: *Maternal nutrition, Epigenetics, Childhood non-communicable diseases, Clinical pharmacist, Fetal programming.*

1. Introduction:

Children and young people make non-communicable diseases (NCDs) to be a health issue of global concern, including obesity, diabetes type 2, heart problems, and chronic lung disease. They single out early life exposures as risk factors in most deaths and morbidity causes related to NCDs, but prenatal and early postnatal life periods are the key ones. There is growing incidence of obesity, insulin resistance and asthma among children which has led to change in pre-emptive efforts that were originally directed to child health care towards maternal health care.[(1) (2)] This is particularly so when it comes to low- and middle-income countries (LMICs) in which there are rapid shifts in diets that cause maternal undernutrition and at the same time result in lack of preventive healthcare.

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According to the concept of Developmental Origins of Health and Disease (DOHaD), an unhealthy mother can influence the concept by affecting the future development of the fetus towards obesity and other metabolic problems.[3] The nutrition of the mother is of paramount importance in determining the development progress of the fetus and the manner in which he or she will be metabolically programmed, in situations where there is lack of or inadequate provision of the necessary nutrients, the fetus would be quick to have a metabolic shift which will ultimately make him/her more susceptible to contracting chronic illnesses once he/she grows up.[4]

Some of the epigenetic mechanisms which are responsible in the effect of the maternal diet on the fetus in regards to the expression of metabolism, immunity and inflammation via the fetal genes are silencing and activation of genes using the addition or removal of methyl groups altering the conformation of the histones which are bound to the DNA and control of non-coding RNAs.[5] Because the direct measurement of the epigenetic state in communities is ethically and logistically challenging, the most common proxy measures that have been used to indicate the risk of epigenetically mediated diseases include the birth weight, gestational age, and duration of breastfeeding.

Some of the nutrients such as folate, vitamin B12, iron, vitamin D, and protein play a major role during pregnancy not only in the development of the fetus, but also in epigenetics.[6] Absence or inadequate level of these nutrients could have resultant effects that could include low birth weight, weakening immune formation and predisposition to obesity, diabetes and cardiometabolic diseases in adulthood. In addition, metabolic and inflammatory risks of the newborn are enhanced by the fact that the maternal diet that is largely composed of high-energy ultra-processed foods.[7][8]

The association between maternal nutrition and childhood non-communicable diseases (NCDs) is becoming increasingly strong on a daily basis yet, the level of available data concerning this issue remains very poor, particularly in the low- and middle-income countries (LMICs).[9] Majority of the research done thus far had been done in hospitals or in high-income countries that minimizes the relevance of the findings to other settings. Moreover, it is common that maternal health studies fail to consider the combination of both the nutritional and pharmacological factors despite the widespread use of supplements and medications in pregnant women.[10]

The clinical pharmacists are playing an increasing role in the maternal and child health arena by providing nutrition counselling, drug safety and encouraging adherence to supplements. Their involvement might increase the extent of enlightenment among mothers, avoid any abuse of drugs, and help achieve the NCD prevention at an early stage of life.[11] It is what the community-based study has done it bridged the gap in the current data by considering the nutritional assessment, measures of medications use, and deriving the indicators of epigenetic risk based on the perspective of the clinical pharmacist, and thereby, evidence was provided to support the preventive strategies led by the pharmacist, which are supposed to reduce the risk of intergenerational NCD.[12]

2. Aim and Objectives

The aim of this study is to assess the dietary practices of pregnant mothers and identify nutritional, clinical, and awareness-related factors that may act as epigenetic risk proxies for the development of non-communicable diseases in children, while exploring the preventive role of clinical pharmacists in prenatal care.

2.1 Primary Objective

The primary objective of the research is to assess the dietary practices of pregnant mothers and predictors that could be regarded as epigenetic risk proxy markers of the genesis of non-communicable diseases (NCDs) in children, in a community-based way.

2.2 Secondary Objectives

1. To monitor the consumption of the primary macro- and micronutrients by the mothers that can have the capacity to alter the epigenetic modulation; these are folate, iron, vitamin D and protein.
2. To identify the adherence level of the mothers to taking the prenatal vitamins and the level at which the mothers used medicine during their pregnancy.
3. To disclose the prenatal and postnatal epigenetic risk proximities including low birth weight, preterm birth, and the duration of breast feeding.
4. To determine the awareness level of mothers with respect to the relation between the pregnancy diet and the risk of NCD among children.
5. To explore the role of clinical pharmacists in the field of prenatal nutrition education, medication errors, and prevention of childhood NCDs at their initial stages.

3. Methodology

3.1 Study Design

In this study, a community-based, cross-sectional, retrospective study was adopted to gain access to the consumption of various types of food by mothers and determine the epigenetic risk proxy indicators that are selective and linked to NCDs in children. Cross-sectional approach was appropriate to evaluate current eating behaviours, prophylactic behaviours, exposure to medications, and the outcome of early life simultaneously in the study group by using retrospectively gathered data.

3.2 Study Setting

The study was conducted in the urban areas, semi-urban and rural areas which were selected, hence; contributing to the fact that participants represented different socio-economic and nutrition conditions. The use of community-based data collection enabled a more accurate representation of the actual maternal practices being conducted outside hospitals and this is particularly true in low- and middle-income countries where

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a significant proportion of the antenatal care being given is outside of tertiary healthcare facilities.

3.3 Study Population

The participants in the study were postnatal mothers who had recently given birth and whose infants or toddlers were from 0 to 5 years old and lived in the selected areas. Mothers living in the selected communities were identified and recruited through visits to the community, health clinics, and local outreach activities. This selection of mothers made it possible to evaluate retroactively not only the maternal exposures during pregnancy but also early-life indicators in children. A total of 210 mothers were included in the study (n = 210) for a period of 1 year (September 2024- September 2025).

3.4 Inclusion and Exclusion Criteria

Inclusion criteria:

- Postnatal mothers of 18 years or older.
- Mothers with a live-born child aged between 0 and 5 years.

Exclusion criteria:

- Mothers suffering from chronic diseases that significantly impact their nutritional status (e.g., cancer).
- Children with diagnosed congenital malformations or inherited diseases.
- Mothers who cannot understand the survey language.

3.5 Sample Size Estimation

The sample size was calculated using a prevalence-based formula, assuming 50% prevalence to maximize sample size, with a 95% confidence interval and 5% margin of error. After adjusting for potential non-response, 250 records were included. Convenience sampling was used, ensuring representation across demographic groups. Data were retrospectively collected from google forms submissions, and only complete records meeting inclusion criteria were analysed.

3.6 Data Collection Tool

Data were collected using a structured, pre-validated questionnaire developed based on existing literature and expert input, including contributions from clinical pharmacists and public health professionals. The questionnaire was administered through Google forms, facilitating efficient data capture and minimizing manual data entry errors. The tool comprised multiple sections covering socio-demographic characteristics, maternal nutritional patterns during pregnancy, supplement adherence, medication use, lifestyle factors, neonatal outcomes, and maternal awareness regarding childhood non-communicable disease (NCD) risk.

Maternal dietary intake during pregnancy was assessed using frequency-based questions focusing on key food groups, including fruits, vegetables, pulses, dairy products, animal protein sources, and ultra-processed foods. Use of nutritional supplements, particularly iron–folic acid, calcium, and vitamin D, was evaluated along with reported adherence patterns. Medication use during pregnancy, including over-the-counter and non-prescribed drugs, was documented to assess potential drug–nutrient interactions and medication safety concerns from a clinical pharmacist perspective.

3.7 Study Variables

The study group consisted of the postnatal mothers who had just given birth and whose children or toddlers were aged in 0-5 years and resided in the chosen locations. The mothers in the target communities were selected and recruited by visiting the community and health clinics as well as local outreach initiatives. This choice of mothers allowed bringing into consideration not only maternal exposures in pregnancy but also childhood markers.

3.8 Epigenetic Risk Proxy Indicator:

Because of the difficulties in the direct measurement of epigenetics in a community context, proxy measures of indicators that are often linked to epigenetic programming and non-communicable disease (NCD) risk were employed. These were low birth weight (less than 2.5 kg), preterm birth (less than 37 weeks of gestation), and inadequate length of exclusive breastfeeding (less than 6 months). These markers are substantiated by the current literature as childhood predictors of metabolic and immune programming.

4. Epigenetic Risk Indicators and Conceptual Framework:

Epigenetic processes are an essential connection between maternal nutrition in pregnancy and the eventual health of the offspring by controlling expression without changes in the sequence of DNA, mainly due to DNA methylation, histone modification, and non-coding RNA action. Such processes are extremely sensitive to the environment during fetal development and pregnancy is one of the major occasions of epigenetic programming. Epigenetic changes to persistent changes in metabolic, endocrine, and immune systems may predispose children to non-communicable diseases (NCDs).[13]

Direct measurement of epigenetic changes in this community study was not possible due to cost and technical constraints. Thus, indicators of epigenetic risks proxy, such as low birth weight, preterm birth, and years of exclusive breastfeeding, were utilized. The low birth weight indicated poor intrauterine nutrition and was associated with the increased risk of insulin resistance and cardiovascular disease.[14] Pre-term birth had an impact on the maturation of organs and immune functioning and reduced the duration of exclusive breastfeeding exposure predisposed to obesity, diabetes and allergy diseases.

The researchers used the Developmental Origins of Health and Disease (DOHaD) model in which upstream factors influencing fetal epigenetic programming included maternal nutrition, supplementation, exposure to medications, and lifestyle. Interventions that could be mitigated by clinical pharmacists such as nutrition counselling, supplement

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adherence monitoring and medication safety education were modifiable mediators that could reduce adverse programming of epigenetics and intergenerational risk of developing NCD.[15] The Present study has been reviewed and approved by the Institutional Ethics Committee (IEC).

5. Statistical Analysis:

The data obtained by the use of Google Forms were export to Microsoft Excel and analysed with the Statistical Package of the Social Sciences (SPSS), Data cleaning and coding Data cleaning and coding were done before analysing.

Mean and standard deviation were the measures of central tendency used to describe continuous variables (mothers age and time of exclusive breastfeeding), whereas frequencies and percentages were the measures of central tendency used to describe categorical variables. The frequency of consumption of the major food groups was entered and a composite maternal nutrition score was derived with higher scores indicating better nutrition quality. Adherence scores on the supplements were based on intake of iron-folic acid, calcium, and vitamin D.

The indicators of epigenetic risk proxies were divided into low weight of birth (less than 2.5 kg), preterm birth (less than 37 weeks of gestation), and insufficient exclusive breastfeeding (less than 6 months). Chi-square tests were used to determine the association between maternal nutrition categories, supplement adherence and birth outcomes. The effect of pharmacist-led counselling on the adherence to supplements as well as maternal awareness was also assessed. The p-value was concluded to be statistically significant when less than 0.05 was used and showed the results in tables and figures.

6. Results

6.1 Socio-Demographic Characteristics of the Study Population

The final analysis included 210 postnatal mothers in total (n = 210). The average Mean ± SD maternal age at the time of pregnancy was 26.8 ± 4.3 years. Most of the mothers lived in semi-urban areas (42.4%), followed by rural (34.8%) and urban (22.8%) places. Nearly all mothers had at least secondary education, and most of them were housewives during the period of pregnancy.

Variable	*Category*	*Frequency (n)*	*Percentage (%)*	*Mean ± SD*
Maternal age (years)	<25	72	34.3	**26.8 ± 4.3**
	25–30	96	45.7	
	>30	42	20.0	
Residence	Urban	48	22.8	
	Semi-urban	89	42.4	
	Rural	73	34.8	
Education level	Primary or less	51	24.3	
	Secondary	98	46.7	
	Graduate and above	61	29.0	

Table 1. Socio-Demographic Profile of Study Participants (n = 210)

6.2 Maternal Dietary Patterns During Pregnancy

Retrospective dietary assessments indicated that there was a lack of intake of the key nutrient-rich food groups. The daily intake (≥4 days/week) of fruits and green leafy vegetables were reported by just 38.1% and 34.8% of mothers, respectively. On the other hand, 46.2% of the participants reported the frequent consumption of fried and ultra-processed foods.

Food group	*Adequate intake (%)*	*Inadequate intake (%)*
Fruits	38.1	61.9
Green leafy vegetables	34.8	65.2
Dairy products	41.0	59.0
Protein sources	36.7	63.3
Ultra-processed foods	46.2	53.8

Table 2. Frequency of Maternal Food Group Consumption During Pregnancy

A composite maternal nutrition score indicated that 57.6% of mothers fell into the poor nutrition category, while only 18.6% demonstrated good dietary quality during pregnancy.

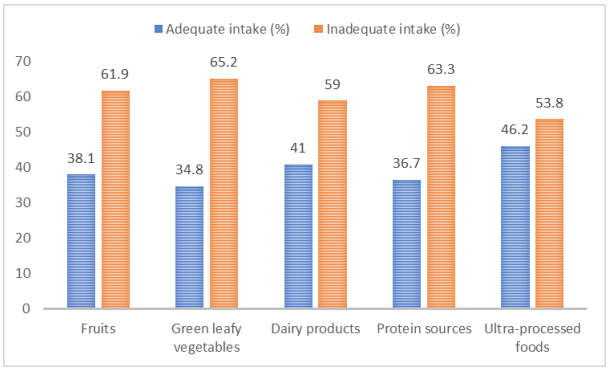

Figure 1. Distribution of Maternal Nutrition Score

6.3 Micronutrient Supplementation and Adherence Patterns

Most mothers were given iron–folic acid (IFA) and calcium supplements, but their adherence throughout pregnancy was not consistent and was low. Regular intake of IFA was reported by only 49.5%, whereas vitamin D supplementation

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was claimed by merely 28.1% of participants with Mean ± SD of 50.72 ± 26.75.

Supplement	*Prescribed (%)*	*Regular adherence (%)*	*Mean ± SD*
Iron–folic acid	88.6	49.5	**50.72 ± 26.75**
Calcium	74.8	44.3	
Vitamin D	28.1	19.0	

Table 3. Prenatal Micronutrient Supplement Use and Adherence

Non-adherence was mainly attributed to gastrointestinal discomfort, forgetfulness, and lack of counselling regarding long-term benefits.

6.4 Prevalence of Epigenetic Risk Proxy Indicators

Analysis of early-life outcomes showed a considerable prevalence of epigenetic risk proxy indicators. Low birth weight (<2.5 kg) was reported in 23.8% of children, while 18.6% were born preterm. Exclusive breastfeeding for less than six months was reported by 41.9% of mothers with 28.10 ± 12.23 as overall Mean ± SD.

Indicator	*Frequency (n)*	*Percentage (%)*	*Mean ± SD*
Low birth weight	50	23.8	**28.10 ± 12.23**
Preterm birth	39	18.6	
Exclusive breastfeeding <6 months	88	41.9	

Table 4. Prevalence of Epigenetic Risk Proxy Indicators

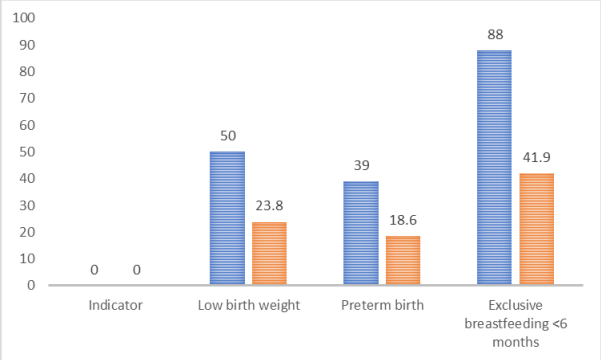

Figure 2. Prevalence of Epigenetic Risk Proxy Indicators

6.5 Association Between Maternal Nutrition and Early-Life Outcomes

Children born to mothers with poor nutrition scores had a significantly higher prevalence of low birth weight and preterm birth compared to those with moderate or good nutrition scores ($p < 0.05$). Similarly, irregular supplement adherence was significantly associated with adverse birth outcomes.

Nutrition score	*Low birth weight (%)*	*Preterm birth (%)*	*P-Value*
Poor	31.4	25.6	**< 0.05**
Moderate	18.2	14.0	
Good	9.1	6.4	

***p-value < 0.05 was considered statistically significant**

Table 5. Association Between Maternal Nutrition Score and Birth Outcomes

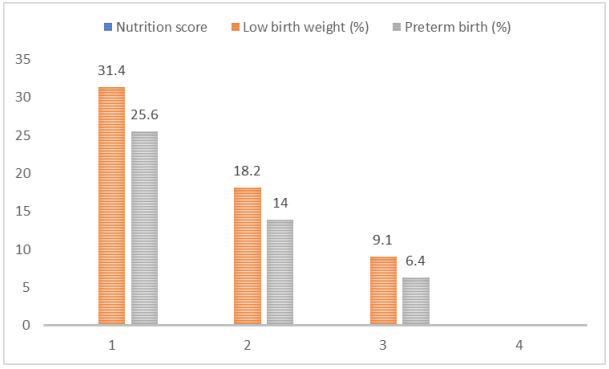

Figure 3. Relationship Between Maternal Nutrition Score and Low Birth Weight

6.6 Maternal Awareness and Role of Clinical Pharmacists

Only 32.9% of mothers were aware of the relationship between maternal nutrition and future NCD risk in children. Pharmacist-led counselling during pregnancy was reported by 21.4% of participants. Mothers who received pharmacist counselling showed significantly better supplement adherence and breastfeeding practices ($p < 0.05$).

Variable	*Yes (%)*	*No (%)*	*P- Value*
Awareness of nutrition–NCD link	32.9	67.1	**< 0.05**
Received pharmacist counselling	21.4	78.6	
Improved adherence with counselling	62.2	37.8	

p-value < 0.05 was considered statistically significant
Table 6. Maternal Awareness and Pharmacist Involvement

7. Discussion

This community-based retrospective study shows that poor maternal nutrition and low supplement intake are still widespread, especially in low- and middle-income countries, and they are still very much involved in creating early-life epigenetic risk factors linked to childhood non-communicable diseases (NCDs). The global evidence that little and unevenly spread progress has been made in the area of maternal undernutrition confirms these findings. Continuing with the statement of Victora et al. (2021), insufficient dietary diversity was a prominent feature, particularly reflected in very low consumption of fruits, vegetables, dairy, and quality protein.[16] The pattern of eating ultra-processed and energy-rich foods was also very common and this has been explained by Brouwer et al. (2021) as a major food system challenge,

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which revealed that maternal and fetal health were predominately affected by dietary quality rather than caloric intake.[17]

The mentioned dietary patterns are probably one of the reasons for the problem of micronutrient deficiency and the adverse metabolic programming of the fetal organism. Although routine antenatal care included the provision of iron–folic acid and calcium supplements, the patients' compliance was very low and the main reasons for that were poor counseling, side effects, and lack of awareness. These results are in line with those of Georgieff et al. (2019), who insisted that the effectiveness of supplementation is heavily reliant on proper instruction and monitoring.[18] Moreover, the very little use of vitamin D supplements points to the continued need for improvement in antenatal nutritional practices.

The evidence that maternal nutrition is a factor to determine health outcomes over generations is strongly supported by the high incidence of epigenetic risk proxy indicators low birth weight, preterm birth, and non-optimal exclusive breastfeeding. Cowardin et al. (2023) and Calcaterra et al. (2025) corroborated the very same associations of early nutritional exposures with long-term metabolic risk, thus pointing out the need for early preventive strategies even more.[19][20]

However, this research unveils the hidden aspect of clinical pharmacists being involved in maternal health care. The activities of a pharmacist as the backbone of the maternal health care system would not only the pregnant women who are taking the supplements but also the medications' safety, and at the same time, the nutritional counseling that goes on at the community level will be improved, thus reinforcing the NCDs prevention efforts coming from the early life stage.

8. The Clinical Pharmacist and Maternal Nutrition and NCD Prevention

Clinical pharmacists provided their services in the area of antenatal care by providing nutrition counselling, encouraging adherence to micronutrients, and giving advice on medication safety. This participation helped in correct utilization of the supplements, reduced drug-nutrient interaction and enhanced maternal knowledge of the lasting health impacts of nutrition and medication intake during pregnancy. Applying clinical pharmacists to community-based maternal health initiatives can lower the predisposition to epigenetically mediated childhood NCD. In the mentioned research, the pharmacist-led counselling was linked to a better adherence to the supplements (62.2%), which emphasizes the practical effect of the pharmacist intervention.

9. Limitations of the Study

This study was associated with some limitations, despite being strong. The cross-sectional nature of the study restricted causal relationship development between childhood non-communicable disease (NCD) risk factors and maternal nutritional habits. The data was self-reported and thus liable to recall and social desirability bias especially on dietary intake and adherence to supplements. Indirect evaluation of underlying epigenetic modifications was not allowed using epigenetic risk proxy indicators, including birth weight and the lifespan of breastfeeding. As well, the findings could have been limited in the generalizability by convenience sampling. However, the research was useful at the community level and could be used as a basis to conduct longitudinal and mechanistic studies in the future.

10. Conclusion

This community-based survey identified maternal nutrition in pregnancy as a critical determinant of early-life indicators of the risk of childhood non-communicable diseases based on epigenetic characteristics. The non-optimal dietary habit, inconsistent micronutrient supplementation, and the lack of maternal literacy were linked to poor birth parameters, premature birth, and the reduction of the period of exclusive breastfeeding. These results highlighted the importance of preventive measures on maternal health at an early stage to reduce the intergenerational problem of NCDs.

The paper also revealed the possibilities of clinical pharmacists in the antenatal and community health environment. Pharmacists can play a crucial role in preventing NCDs at an early stage through nutrition counselling programs, better supplement compliance, medication care monitoring, and maternal education. The introduction of pharmacist-led services into the programs of maternal and child health could enhance preventive healthcare and outcomes.

Longitudinal designs must be undertaken in future studies and direct epigenetic measurements are necessary to help understand causal pathways. The interdisciplinary approach with clinical pharmacists as a significant part of the maternal nutrition and NCD prevention programs should be of priority to policymakers and healthcare systems.

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Conflict of Interest

The authors declare that **there are no conflicts of interest** related to this study.

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