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CONGENITAL MALFORMATIONS OF THE CENTRAL NERVOUS SYSTEM AMONG NEWBORNS DELIVERED AT TERTIARY HEALTH CARE HOSPITAL IN INDIA: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Malformations of the central nervous system (CNS) are a significant contributor to childhood morbidity and death. Congenital CNS abnormalities may result in long-term disability that affects not only the child's development and well-being but also families, the medical system, and society as a whole. **Purpose:** The purpose of this study is to determine the incidence, type, and associated risk factors of CNS malformations in newborns who were delivered to the Obstetrics and Gynecology department of Netaji Subhash Chandra Bose Medical College (NSCB Medical College). **Methods:** An observational hospital-based study was carried out in the departments of pediatrics and obstetrics and gynecology at the NSCB Medical College and Hospital in Jabalpur. Data was entered into MS Excel, and IBM-SPSS 23.0 was used to perform descriptive and inferential statistical analysis. During a one-year study period, 40 cases of CNS malformation out of 7117 deliveries were found to have occurred either before or after birth. **Results:** During the study period, 40 cases of CNS malformation out of 7117 deliveries were identified either prenatally or at birth, making an incidence of 0.5%. Of all CNS anomalies, hydrocephalus accounted for 52.5 percent, whereas neural tube defects accounted for 27.5 percent. The other two main CNS abnormalities identified in utero were ventriculomegaly and midline defects. **Conclusion:** This study identified CNS malformations in newborns, with hydrocephalus and neural tube defects as the most common types. Key risk factors included younger maternal age, rural residence, inadequate antenatal care, adverse obstetric history, chronic illness, polyhydramnios, and maternal addiction.

Keywords: congenital, malformations, neural tube defects, CNS, newborns

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INTRODUCTION

Congenital malformations of the central nervous system (CNS) represent a significant concern in neonatal health, contributing substantially to neonatal morbidity and mortality. These malformations encompass a range of structural anomalies that occur due to aberrations in the developmental processes of the brain and spinal cord. Globally, the prevalence of CNS malformations ranges between 0.14 and 0.92 per 1,000 live births. In comparison, India's prevalence, particularly for NTDs at 9.46 per 1,000 births, is notably higher (Sinha *et al*., 2024). This disparity underscores the need for enhanced preventive measures, such as periconceptional folic acid supplementation, improved maternal healthcare, and strengthened surveillance systems to identify and manage these conditions effectively.

The Ministry of Health and Family Welfare in India has implemented programs like the Rashtriya Bal Swasthya Karyakram (RBSK), aiming for early identification and management of birth defects, diseases, deficiencies, and developmental delays in children. While specific numerical targets for reducing CNS malformations are not explicitly stated, India is committed to achieving the Sustainable Development Goal of reducing neonatal mortality to below 12 per 1,000 live births by 2030.

The etiology of CNS malformations is multifactorial, involving genetic predispositions, environmental exposures, nutritional deficiencies, and maternal health conditions. Neural tube defects (NTDs), including anencephaly and spina bifida, are among the most prevalent CNS malformations and are frequently linked to inadequate folic acid intake during pregnancy (Siddesh *et al*., 2017). Other central nervous system malformations, such as hydrocephalus, microcephaly, and holoprosencephaly, pose significant challenges in terms of accurate diagnosis, effective management, and long-term patient outcomes (Eke *et al*., 2016).

India, with its diverse population and varying levels of healthcare access, presents a unique context for studying congenital anomalies. In regions such as Madhya Pradesh, socio-economic inequalities, inadequate access to prenatal care, and nutritional deficiencies contribute to an increased incidence of congenital anomalies (Ghanghoriya *et al*., 2018). The present study focuses on the incidence and pattern of CNS malformations among newborns delivered at a tertiary health care hospital in Jabalpur, Madhya Pradesh, India. By examining demographic, obstetric, and neonatal factors, this study aims to identify potential risk factors and provide insights into preventive strategies and healthcare policies (Patel, 2017; Pandey *et al*., 2019).

This study uniquely contributes to the understanding of congenital central nervous system (CNS) malformations by providing a detailed examination of their prevalence and patterns specifically within a tertiary care hospital in Jabalpur, Madhya Pradesh, India. The research is distinctive in its regional focus, offering insights into a population that has been underrepresented in existing literature. By integrating a range of factors including maternal health, socioeconomic status, and nutritional deficiencies, the study presents a comprehensive analysis of the complex interplay of variables contributing to CNS anomalies. Additionally, it serves as a critical baseline for future research in the region, potentially guiding targeted public health interventions and preventive strategies tailored to local needs.

The novelty of this study lies in its innovative methodology and the introduction of new perspectives on congenital central nervous system (CNS) malformations. Unlike previous research that often relies on data from broader or more generalized populations, this study employs a detailed, localized approach within a specific tertiary care hospital in Jabalpur. It introduces novel analytical frameworks by correlating unique regional factors-such as local dietary practices, environmental influences, and healthcare accessibility-with the incidence of CNS malformations. Additionally, the study integrates recent advancements in diagnostic technologies and data collection methods, offering a contemporary view of the prevalence and patterns of these anomalies. This fresh perspective not only enriches the existing body of knowledge but also paves the way for innovative public health strategies and targeted research in the field.

The findings will contribute to the existing body of knowledge and support the

development of targeted interventions to reduce the incidence and impact of CNS malformations in this region (Singh & Sharma, 2020). There is paucity of literature regarding the local prevalence, the pattern of CNS malformations, and the probable associated risk factors in Madhya Pradesh. This study aims to examine the prevalence and pattern of CNS malformations in newborns delivered at a tertiary care hospital in Jabalpur, providing insight into the contributing factors and outcomes associated with these congenital defects.

METHOD

Study Design

This was an observational study carried out in the departments of pediatrics and obstetrics and gynecology at the Netaji Subhash Chandra Bose (NSCB) Medical College and Hospital in Jabalpur, Madhya Pradesh.

Sampling and Population

This study is carried out in the departments of pediatrics and obstetrics and gynecology at the NSCB Medical College and Hospital in Jabalpur, Madhya Pradesh. The period of study was from August 2022 to January 2024. All the cases were taken till the study period was completed. Using the purposive sampling method, a total of 83 instances with congenital abnormality discovered antenatally or at birth were examined. Out of 83 congenital anomalies, 40 cases of CNS congenital abnormality were identified. After giving their informed agreement, the study included mothers whose fetuses had been classified as abnormal either during the antepartum period or at birth.

Data Source

Research in this article used primary data. Comprehensive data was recorded about the consanguinity, gestational age, maternal age, and the order of pregnancies.

Data Collection

Data collection techniques were conducted using questionnaires. Pregnancy-related histories were documented, including maternal sickness, drug use, radiation exposure, and labor difficulties. The pediatrician performed a complete examination on each newborn to look for congenital malformations. If any internal congenital malformation was suspected further investigation like Ultrasonography, ECHO, X-ray, etc. was done in live babies. Congenital anomalies were diagnosed through physical examination, or various investigations (ultrasonography, 2D echocardiography). This descriptive cross-sectional study involves a detailed analysis of CNS malformations in newborns, highlighting the need for improved prenatal care, nutritional supplementation, and early diagnostic interventions.

Data Analysis

The collected data was tabulated and analyzed using MS-EXCEL and IBM-SPSS version 23.0. The data were expressed in percentages and proportions. The chi-square test was used to obtain an association between dependent and independent variables. A $p<0.05$ was considered significant.

Ethical Clearance

Informed consent was taken from all the study participants. Institutional ethical clearance was obtained before the conduction of the study (No. IEC/2022/8629-81, issued by Institutional Ethical Committee, Medical College, and Hospital, Jabalpur, dated 05.09.2022)

RESULT

The present study was conducted in the Department of Obstetrics and Gynecology & Department of Pediatrics, NSCB Medical College and Hospital, Jabalpur, Madhya Pradesh to assess congenital malformations of the central nervous system in newborns delivered in tertiary health care hospital, Jabalpur, Madhya Pradesh. During the study period, a total of 7,117 deliveries were recorded, among which 83 cases of congenital anomalies were identified. Of these, central nervous system (CNS) anomalies, accounted for 40 cases. It was found that out of 40 cases, hydrocephalus accounted for 52 percent, whereas neural tube defects accounted for 27 percent (Figure 1).

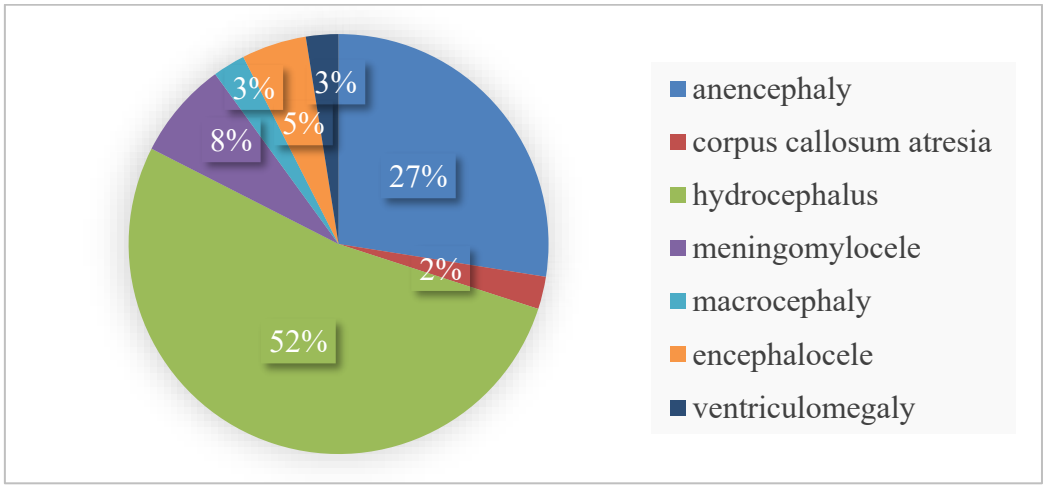

Figure 1. The spectrum of CNS malformations

About 85% of the mothers who delivered CNS-malformed babies were aged less than 30 years. The mean age of the mothers was 25.35± 3.65 SD. Most mothers (60 %) reside in rural areas and are unemployed (52 %). Regarding education, 32.5% had completed high school, while 60% came from socioeconomic class III. Most mothers were Hindu (92.5%), and nearly half (47.5%) were employed. Regarding gravida status, 57.5% were primigravida, 22.5% were second gravida, and 15% were third gravida. The remaining mothers had higher gravida statuses, with 5% being fourth gravida or more (Table 1).

Table 1. Sociodemographic details of the study subjects

Variable	Frequency (n=40)	Percentage (%)
Maternal age		
<30	34	85.0
≥30	6	15.0
Locality		
Rural	24	60.0
Urban	16	40.0
Education of mother		
Illiterate	4	10.0
Primary	11	27.5
Middle	6	15.0
High	13	32.5
Higher Secondary	1	2.5
Graduation	5	12.5
Socioeconomic class		
I	1	2.5
II	5	12.5
III	24	60.0
IV	8	20.0
V	2	5.0
Religion		
Hindu	37	92.5
Muslim	3	7.5
Others	0	0
Occupation		
Employed	19	47.5
unemployed	21	52.5
Gravida		
G1	23	57.5
G2	9	22.5
G3	6	15.0
G4 or more	2	5.0

The obstetric factors of mothers of babies with CNS malformations were compared to those with non-CNS malformations. The non-CNS malformations include malformations of different systems except CNS which is malformations of the gastrointestinal system, cardiovascular system, respiratory system, renal system, skeletal system, etc. Among these systems, CNS malformations were found to be the most common congenital malformation. There was no significant difference in the mode of delivery, with 17 babies in the CNS malformation group and 22 in the non-CNS group born vaginally, and 23 and 21, respectively, by cesarean section (p = 0.569). Regarding gestational age, 20 babies with CNS malformations were born between 28-37 weeks, while 19 were born at 37-42 weeks. For previous bad obstetric history, 22 mothers in the CNS group and 27 in the non-CNS group had such a history, with no significant difference (p = 0.619). Similarly, the history of previous cesarean sections showed no significant difference between the two groups (p = 0.789) (Table 2).

Table 2. Distribution of obstetrics factors among the study subjects

Variable		Malformation		Total N=83(100)	P-Value
		CNS Malformations (n=40) (%)	Non-CNS malformations (n=43) (%)		
Mode of delivery	Normal/vaginal	17 (43.5)	22 (56.4))	39(100)	0.569
	Cesarean	23 (52.2)	21 (47.7)	44(100)	-
Gestational age	28-37 weeks	20 (45.4)	24 (54.5)	44(100)	
	37-42 weeks	19 (52.7)	17 (47.2)	36(100)	
	>42 weeks	1 (33.3)	2 (66.6)	3(100)	
Previous bad obstetric history	Yes	22 (44.8)	27 (55.1)	49(100)	0.619
	No	18 (52.9)	16 (47.1)	34(100)	
History of previous c-section	Yes	17 (51.5)	16 (48.5)	33(100)	0.789
	No	23 (46.0)	27 (54.0)	50(100)	

The gender distribution and birth weight of babies with CNS malformations were compared with those of babies with non-CNS malformations. For gender, there was no significant difference between the groups, with 18 males and 22 females in the CNS malformation group, compared to 17 males and 23 females in the non-CNS group (p= 1.000). Regarding birth weight, 23 babies in the CNS malformation group and 26 in the non-CNS group had low birth weight (<2.5 kg), while 17 babies in each group had normal birth weight. (Table 3).

Table 3. Baseline Neonatal characteristics

Variable		Malformation		Total N=83(100)	P-Value
		CNS Malformations (n=40) (%)	Non-CNS malformations (n=43) (%)		
Gender	Male	18 (51.4)	17 (48.6))	35(100)	
	Female	22 (48.9)	23 (51.1))	45(100)	1.000
Birth weight of the baby	Normal weight	17 (50.0)	17 (50.0))	34(100)	
	Low birth weight (<2.5kg)	23 (46.9)	26 (53.1)	49(100)	0.959

The pregnancy-related factors of mothers with CNS malformations were analyzed in comparison to those with non-CNS malformations. There were no cases of consanguinity in either group. Regarding antenatal care, 11 mothers in the CNS malformation group and 14 in the non-CNS group had regular Fe/FA/Ca tablet

consumption, with no significant difference (p = 0.61). A significant difference was found in the history of chronic illness, with 26 mothers in the CNS group and 23 in the non-CNS group reporting such illnesses (p = 0.028). The status of amniotic fluid was within the normal range for 19 mothers in the CNS group and 23 in the non-CNS group, showing no significant difference (p = 0.586). History of addiction was more common in the CNS malformation group, with 10 mothers reporting smoking, tobacco, or alcohol use, compared to 3 in the non-CNS group. Similarly, the history of unidentified medication use and exposure to radiation showed no significant differences between the groups (p = 0.845 and p = 0.331, respectively) (Table 4).

Table 4. Distribution of maternal risk factor among the study subjects.

Variable		Malformations		Total N=83(100)	P-Value
		CNS Malformations (n=40) (%)	Non-CNS malformations (n=43) (%)		
Consanguinity	Yes	0 (0.0)	0 (0.0)	0(0.0)	-
	No	40 (48.1)	43 (51.8)	83(100)	
Adequate antenatal care (Fe/FA/Ca tablet consumption)	Regular	11 (44.0)	14 (56.0)	25(100)	0.61
	Irregular	29 (50.0))	29 (50.0)	58(100)	
History of any chronic illness	Present	26 (53.1)	23 (46.9)	49(100)	
	Absent	14 (41.2)	20 (58.8)	34(100)	0.028
Status of amniotic fluid	Within normal range	19 (45.2)	23 (54.8)	42(100)	
	Abnormal range	21 (51.2)	20 (48.8)	41(100)	0.586
History of addiction (smoking/tobacco/alcohol)	Yes	10 (76.9)	3 (23.1)	13(100)	0.457
	No	30 (42.8)	40 (57.2)	70(100)	
History of any unidentified medication use	Yes	5 (45.4)	6 (54.6)	11(100)	0.845
	No	35 (48.6)	37 (51.4)	72(100)	
History of exposure to radiation	Yes	0 (0.0)	1 (100)	1(100)	0.331
	No	40 (48.7)	42 (51.3)	82(100)	

DISCUSSION

The present study aimed to assess the prevalence and characteristics of congenital central nervous system (CNS) malformations in newborns delivered at a tertiary healthcare hospital in Jabalpur, Madhya Pradesh. Out of 7,117 deliveries, 83 cases of congenital anomalies were identified, with 40 (48.2%) being CNS malformations. Hydrocephalus (52%) was the most frequent anomaly observed, followed by neural tube defects (27%). These findings align with the study by Dewan *et al*. (2018), which identified hydrocephalus as the leading CNS malformation, reflecting similar trends in neonatal malformations, particularly in developing regions with limited healthcare infrastructure for early diagnosis and prevention strategies. Regarding sociodemographic characteristics, 85% of newborns with CNS malformations were born to mothers under 30 years of age, with a mean maternal age of 25.35 ± 3.65 years. This observation is consistent with the findings of Estevez-Ordonez *et al*. (2017), who suggested that maternal age under 30 years is a significant risk factor for congenital anomalies, particularly neural tube defects. Furthermore, the study revealed that 60% of mothers resided in rural areas, and 52% were unemployed. Gupta et al. similarly observed a higher prevalence of congenital anomalies among rural populations, linking it to limited healthcare access and nutritional deficiencies. Aydın *et al*. (2019) emphasized that lower socioeconomic status, which often correlates with rural residence, is associated with an increased risk of congenital anomalies due to inadequate prenatal care and poor nutrition.

Educational status also emerged as a relevant factor, with 32.5% of mothers having completed high school and 60% belonging to socioeconomic class III. These findings are consistent with research by Gunnarsdottir *et al*. (2019), which highlighted the influence of maternal education on pregnancy outcomes. Mothers with lower educational attainment often have reduced access to information about

prenatal care, contributing to a higher risk of congenital malformations. The predominance of Hindu mothers (92.5%) in this study reflects the local demographics and is unlikely to directly impact the occurrence of CNS malformations, as no significant associations between religion and congenital anomalies have been reported.

In terms of obstetric factors, the mode of delivery, gestational age, and previous obstetric history did not show significant differences between the CNS malformation group and the non-CNS malformation group. Similar findings were reported by Tan *et al*. (2022), who concluded that cesarean sections, mode of delivery, and gestational age were not strongly associated with CNS malformations. However, 57.5% of mothers in the CNS malformation group were primigravida, a finding supported by Nagaraj *et al*. (2022), who noted that first pregnancies carry a higher risk of congenital defects, potentially due to immune responses, maternal age, or lack of prior pregnancy experience.

Pregnancy-related factors such as chronic maternal illnesses were significantly more prevalent in the CNS malformation group (65%) than in the non-CNS group (53.5%), with a p-value of 0.028. Bulut *et al*. (2025) highlighted that chronic conditions like diabetes, hypertension, and thyroid disorders increase the risk of congenital malformations, including CNS defects, due to their impact on fetal development and placental function. Tao *et al*. (2024) also emphasized the importance of managing chronic illnesses during pregnancy to minimize adverse outcomes.

Lifestyle factors, including smoking, tobacco use, and alcohol consumption, were more common in the CNS malformation group (25%) compared to the non-CNS group (7%), although the difference was not statistically significant ($p = 0.457$). These findings are consistent with the work of Manzoor *et al*. (2024), who documented the teratogenic effects of nicotine and alcohol on fetal development, resulting in an increased risk of neural tube defects and other CNS anomalies. While this study did not find significant differences, it underscores the need for public health initiatives to reduce substance use during pregnancy. Interestingly, no significant differences were observed between the groups in terms of antenatal care, including Fe/FA/Ca tablet consumption ($p = 0.61$). This contrasts with the findings of Viswanathan *et al*. (2023), who demonstrated that folic acid supplementation significantly reduces the incidence of neural tube defects.

This study provides a comprehensive analysis of congenital central nervous system (CNS) malformations among newborns delivered at a tertiary care hospital in Jabalpur, Madhya Pradesh. The findings reveal a significant prevalence of CNS anomalies, underscoring the importance of understanding local patterns and contributing factors. The study highlights that neural tube defects, such as anencephaly and spina bifida, are prevalent, reflecting similar trends observed in other regions with limited access to prenatal care and nutritional resources. Firstly, it is based on data from a single tertiary care hospital in Jabalpur, which may limit the generalizability of the findings to other regions or populations with different healthcare access and socio-economic conditions. Moreover, the study does not include long-term follow-up data on the developmental outcomes of affected infants and may not account for all socio-economic variables, such as detailed nutritional and environmental factors. Additionally, the relatively small sample size might not fully capture the spectrum of CNS anomalies, and there may be unmeasured confounding variables that influence the results. These factors highlight the need for larger, multi-center studies to validate and expand upon the findings.

CONCLUSION

This study confirms that congenital CNS malformations remain a significant neonatal health challenge, with hydrocephalus and neural tube defects as the leading anomalies. A significant association was observed between CNS malformations and a history of chronic illness in mothers. Additionally, a higher prevalence of addiction (smoking, tobacco, or alcohol use) was noted in the CNS malformation group. These findings highlight the importance of managing maternal health, especially chronic illnesses, to reduce the risk of CNS malformations. Further research is needed to explore other maternal factors influencing congenital anomalies.

SUGGESTION

Based on the findings of this study, it is recommended that prenatal care programs must integrate operational strategies focused on prevention, early detection, and intervention. Routine ultrasound screenings and advanced diagnostic tools like fetal MRI should be mandated for high-risk pregnancies, supported by mobile health units to improve antenatal care access in remote areas. Targeted health education campaigns led by community health workers should promote periconceptional folic acid supplementation, coupled with the distribution of free or subsidized folic acid tablets in underserved regions. High-risk pregnancy clinics at district hospitals should offer multidisciplinary care for mothers with chronic illnesses, while neurodevelopmental follow-up programs must be established to monitor affected newborns and provide rehabilitative services like physical and speech therapy. A national registry for congenital anomalies should be implemented to improve data collection and evaluate intervention outcomes. Additionally, public-private partnerships can enhance resources for outreach, while policy-level initiatives such as mandatory food fortification with folic acid and digital health solutions, including mobile apps for ANC reminders and telemedicine, can ensure widespread access to preventive and diagnostic services. These operational steps collectively aim to reduce the prevalence and impact of CNS malformations across India.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest to disclose.

DECLARATION OF ARTIFICIAL INTELLIGENCE (AI)

The authors acknowledge the use of ChatGPT for summarization and Grammarly for language refinement in preparing this manuscript. All AI-generated content was rigorously reviewed, edited, and validated to ensure accuracy and originality. Full responsibility for the manuscript's final content rests with the authors.

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AUTHOR CONTRIBUTION

Author Shashi Prabha Tomar and Preeti Gupta contributed to the design of the study, guidance, supervision, and review work for the research. Author Sangeeta Devaliya and Vaishali Soni contributed to collecting the articles, preparing the draft along with data analysis, and the final manuscript was read and approved by both.

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