RESEARCH PAPER

A Cross-Sectional Study on Assessment of Hearing in Neonates of Gestational Diabetic Mothers

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Received: 02nd Jun, 2026; Revised: 15th Jul 2026; Accepted: 05th Aug, 2026; Available Online: 12th Aug, 2026

ABSTRACT

AIMS:

The study was aimed to establish the relationship between congenital hearing impairment in newborns and gestational diabetes mellitus through transient evoked otoacoustic emissions (TEOAE).

METHODOLOGY:

This observational study was carried out over a period of 18 months. All the 66 neonates were categorized into two groups, i.e. the neonates born to mothers with gestational diabetes mellitus (GDM group) and those born to non-diabetic mothers (control group). Maternal baseline characteristics were taken. TEOAE screening of all neonates was carried out initially and repeat OAE was done in cases of refer results. Referred cases underwent Brainstem Evoked Response Audiometry (BERA). The statistical test of Chi-square test was carried out with a p value of 0.05 taken to be statistically significant.

RESULTS:

Mean maternal age, HbA1c and OGCT values were found to be significantly high in the GDM group ($p < 0.05$). At the first OAE encounter, 48.5% of GDM group neonates reported with refer OAEs results against 9.1% of the control group ($p = 0.001$). Follow-up OAE testing revealed that 43.8.% of the neonates in the GDM group had persistent abnormal outcomes as compared to 33.3% of the neonates in the control group ($p = 0.032$). A higher proportion of the neonates born of GDM-mothers needed to be referred to undergo BERA ($p = 0.02$).

CONCLUSION:

Born neonates of mothers with gestational diabetes mellitus reported much higher abnormal otoacoustic emission findings than the controls did, indicating premature cochlear abnormality. These results emphasize the significance of specific hearing and audiological follow-up screening of infants born to diabetic mothers.

Keywords: Gestational diabetes mellitus, neonatal hearing loss, otoacoustic emissions, congenital hearing impairment, TEOAE, BERA.

How to cite this article: Adlin Shiji AS, Ravi KS, Tej Pavan J, Chaitra KC, Thyvalath Divya Ramesh. A Cross-Sectional Study on Assessment of Hearing in Neonates of Gestational Diabetic Mothers. Int J Drug Deliv Technol. 2026;16(75s): 1114. DOI: 10.25258/ijddt.16.75s.117

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Hearing is one of the most important sensory modalities essential for the normal growth and development of a child, particularly during early infancy. Auditory input during the first few months of life plays a critical role in the development of speech, language acquisition, cognitive abilities, emotional regulation, and social interaction. Adequate hearing stimulation during this sensitive period supports neural plasticity and the maturation of auditory pathways, which are fundamental for later communication skills [1,2].

Globally, congenital hearing loss is one of the most common chronic conditions of childhood, with an estimated prevalence of approximately 1–3 per 1000 live births in developed countries [3]. Congenital or early-onset hearing impairment, if undetected at birth, can result in delayed speech and language development, poor academic performance, and long-term psychosocial difficulties [2,4]. Parental recognition and clinical suspicion are often delayed, underscoring the importance of objective screening methods for early identification [4,5].

The Joint Committee on Infant Hearing (JCIH) recommends the widely accepted "1-3-6" protocol, which includes hearing screening by one month of age, confirmatory diagnosis by three months, and initiation of early intervention services by six months of age [6]. In addition to universal screening, the JCIH has identified several neonatal and perinatal risk factors associated with an increased likelihood of hearing impairment [7]. Recently, attention has shifted toward maternal metabolic conditions during pregnancy, particularly gestational diabetes mellitus (GDM), as potential contributors to altered fetal auditory development.

Gestational diabetes mellitus is one of the most common metabolic complications of pregnancy and is characterized by glucose intolerance with onset or first recognition during pregnancy [8]. The global prevalence of GDM has increased substantially over recent decades, especially in low and middle-income countries undergoing rapid urbanization and lifestyle transitions [8,9]. Infants born to mothers with GDM are at higher risk of neonatal complications such as macrosomia, hypoglycemia, respiratory distress, preterm birth, and hyperbilirubinemia—conditions that themselves are known to adversely affect the developing auditory system [10,11].

Beyond these indirect effects, experimental and clinical evidence suggests that chronic intrauterine exposure to maternal hyperglycemia may directly impair fetal auditory development through mechanisms involving placental dysfunction, fetal hypoxia, oxidative stress, and microvascular alterations. The cochlea, particularly during late gestation, is highly sensitive to hypoxic and metabolic insults, and even transient disturbances in oxygenation may disrupt cochlear microstructure and function. [12].

Given these observations, several clinical studies have evaluated hearing outcomes in neonates born to mothers with gestational diabetes using screening tools such as transient evoked otoacoustic emissions (TEOAE), distortion product otoacoustic emissions (DPOAE), and auditory brainstem response (ABR) testing [13,14]. While some studies report higher failure rates on initial hearing screening and subtle electrophysiological abnormalities in this population, others have found no significant association, particularly in cases with good glycemic control and absence of additional risk factors [13]. These inconsistencies highlight the need for further region-specific evidence, especially in high-burden settings such as India.

MATERIALS AND METHODS

Study Design and Setting:

This was a cross-sectional observational study conducted over a period of 18 months from July 2024 to January 2026 in the Department of ENT at our institute. All subjects provided written informed consent to participate in the study. The study received ethical clearance from Institutional Ethical Committee.

Study Population:

A total of 66 neonates were included in the study, of whom 33 were born to non-gestational diabetic mothers and 33 were born to mothers with gestational diabetes mellitus. Patients were recruited from the obstetric and pediatrics department of the hospital. The study aimed to assess hearing impairment through TEOAE outcomes in neonates of Gestational diabetic mothers.

Inclusion criteria:

- Neonates of mothers with gestational diabetes mellitus form the exposed group.
- Neonates of mothers without gestational diabetes mellitus form the non-exposed group.

Exclusion criteria:

- Mothers with previous history of diabetes.
- Mothers with other comorbidities.
- Infants with risk factors like low APGAR, Low birth weight, meningitis, ototoxic drugs, infections and any other congenital deformities.

Study design and data collection:

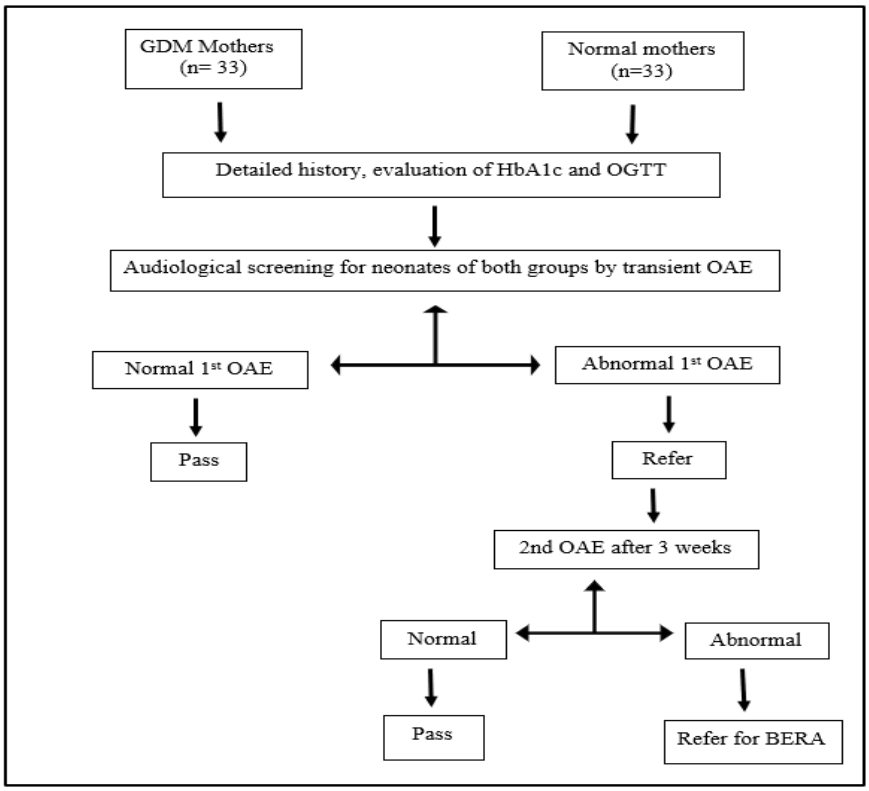

Figure 1: Study design

Statistical analysis:

All collected data were entered into a Microsoft Excel spreadsheet and analyzed using SPSS software. Descriptive statistics were expressed in percentages and mean ± standard deviation. The Chi-square test or fisher's exact test was used to assess the significance of categorical variables, with a p-value < 0.05 considered statistically significant.

RESULTS

The study was conducted in the Department of ENT over a duration of 18 months from July 2024 to January 2026. Patients were recruited from the obstetric and pediatrics department of the hospital. The mean age, HbA1c, and OGCT values were significantly higher among mothers with gestational diabetes mellitus compared to non-diabetic mothers (Table 1), and the difference was statistically significant ($p < 0.05$). These results prove the existence of clear metabolic differentiation between the exposed and the non-exposed groups.

Variable	GDM Mother (Mean ± SD)	Non GDM Mother (Mean ± SD)	p-value
Age (years)	28.51 ± 3.11	26.58 ± 3.35	0.018*
HbA1c (%)	6.07 ± 0.36	5.17 ± 0.28	0.001*
OGCT (mg/dl)	166.27 ± 21.03	114.24 ± 12.52	0.001*

Table 1: Comparison of baseline characteristics of GDM and non-GDM mothers

The number of LSCS and vaginal deliveries are comparable in both groups. There was no statistically significant association between gestational diabetes status and mode of delivery. Gender distribution of the neonate was also comparable between both groups with no statistically significant difference (Figure 2).

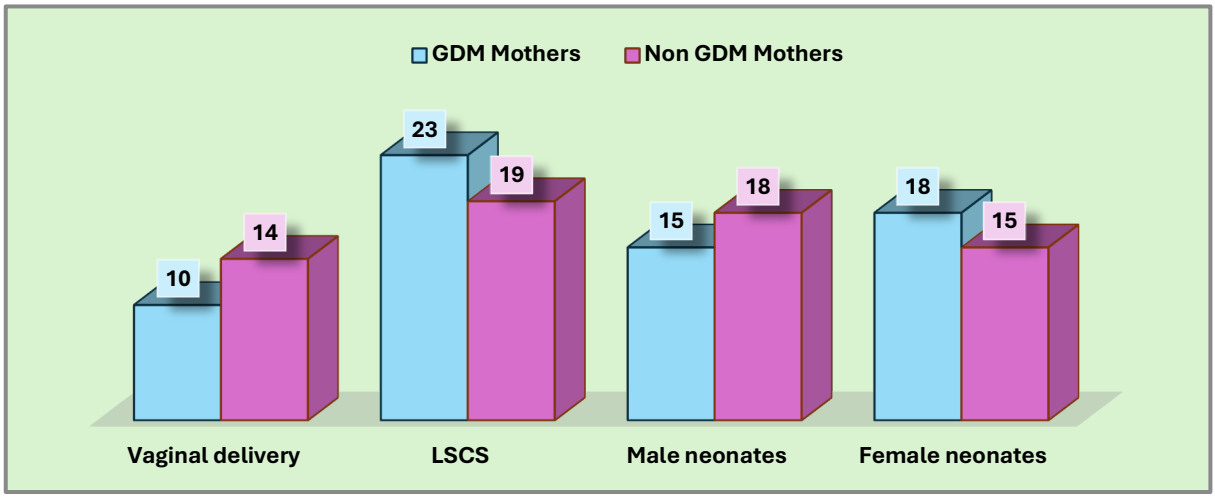

Figure 2: Mode of delivery and gender distribution

In the intial OAE screening, a significantly higher proportion of neonates born to GDM mothers (16 neonates - 48.5%) had "refer" results compared to neonates of non-GDM mothers (3 neonates - 9.1%). The statistical significance between the two groups was very high (p = 0.001) (Figure 3). This shows that the rates of referrals of the neonates born to the mothers with gestational diabetes were more than five times higher than those of the neonates born to the mothers with non-diabetes.

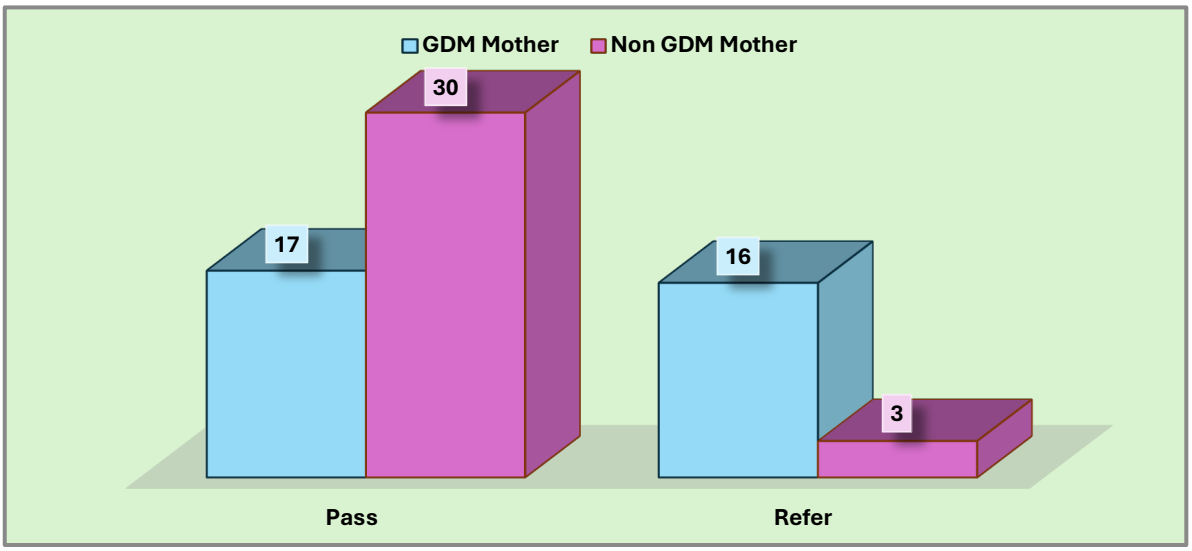

Figure 3: Comparison of initial OAE screening outcome

Infants that failed the initial screening were retested with OAE after a reasonable delay. This was done to exclude transient causes of screening failure. In the GDM group: 9 neonates (56.2%) passed, 7 neonates (43.8%) still had refer results. In the control group: 2 neonates (66.7%) passed. Persistent results of refer were only 1 (33.3%) neonate. The significance of the difference was still statistically significant (Table 2). These data also confirm the higher chances of auditory impairment among the neonates of women with gestational diabetes.

Table 2: Comparison of follow-up OAE outcome

Study group	Pass n (%)	Refer n (%)	p-value
GDM Mother	9 (56.2%)	7 (43.8%)	0.032*

Non GDM Mother	2 (66.7%)	1 (33.3%)	

Neonates with persistent "refer" results on follow-up OAE were referred for Brainstem Evoked Response Audiometry (BERA) for confirmatory diagnosis. Parents were counselled regarding the need for further evaluation and follow-up. While 21% of neonates from GDM group got referred, only 3% of the neonates of normal mother required referral indicating a significant association between gestational diabetes and neonatal hearing (Figure 4).

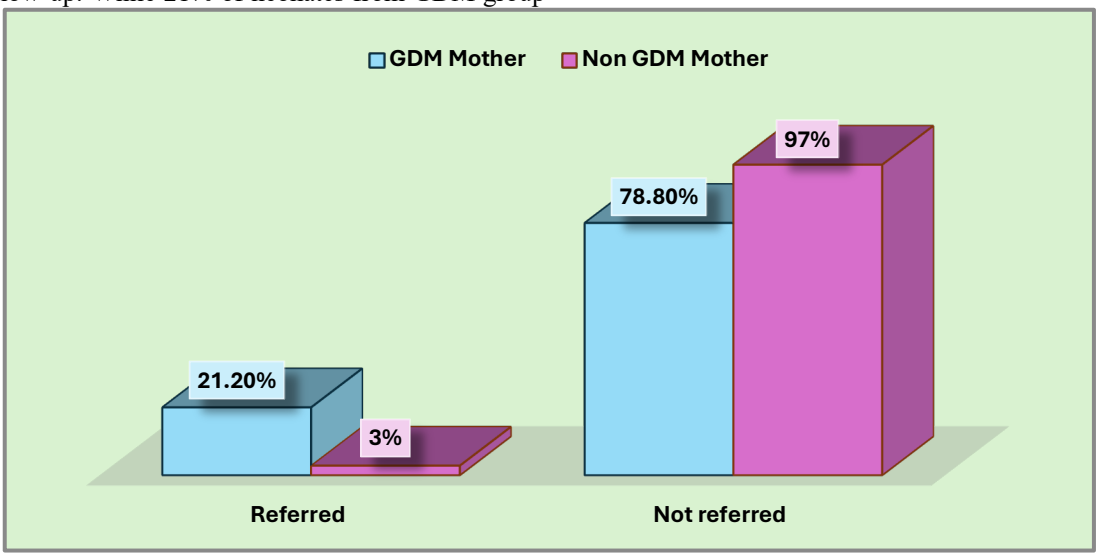

Figure 4: Distribution of neonates referred for BERA

DISCUSSION

Gestational diabetes mellitus (GDM) is a metabolic disorder characterized by glucose intolerance first recognized during pregnancy. Although its maternal and neonatal metabolic complications are well documented, its potential impact on fetal auditory development has gained increasing attention. The present cross-sectional comparative study was conducted to evaluate hearing outcomes in neonates born to mothers with gestational diabetes mellitus using transient evoked otoacoustic emissions (TEOAE), with follow-up testing and BERA referral where indicated. The findings are discussed below in comparison with available Indian and international literature.

Demographic Profile: Indian and Global Background

In the present study, mothers with gestational diabetes mellitus were significantly older compared to non-diabetic mothers ($p < 0.05$). Advanced maternal age is a well-established risk factor for GDM and has been similarly reported in Indian studies by Sharma et al. and Amrutha et al [15,16]. International studies also demonstrate increasing GDM prevalence with advancing maternal age [17].

Gender distribution among neonates was comparable between the two groups, with no statistically significant association. Similar findings have been reported in both Indian and global literature, suggesting that neonatal gender does not independently influence hearing screening outcomes [17].

Maternal Glycemic Status and Clinical Correlation

The present study showed significantly higher HbA1c and OGCT values among mothers with GDM ($p < 0.001$), confirming appropriate group stratification. Poor glycemic control has been shown to correlate with adverse neonatal outcomes. Langer et al. emphasized that the severity and duration of maternal hyperglycemia determine fetal complications [18].

Indian studies evaluating neonatal hearing in GDM pregnancies also highlight the role of glycemic control in determining screening outcomes [16]. These findings support the hypothesis that chronic intrauterine exposure to hyperglycemia may affect fetal cochlear maturation.

Initial OAE Screening Outcomes: Indian and International Comparison

A significantly higher proportion of neonates born to GDM mothers showed "refer" results on initial OAE screening compared to controls ($p = 0.001$). This observation is consistent with Indian studies by Padmadasan et al. and Sharma et al., who reported increased OAE referral rates among neonates of diabetic mothers [16]. Amrutha et al. also documented higher cochlear dysfunction in infants exposed to maternal diabetes [15].

International evidence supports similar findings. Lee et al. reported higher early auditory abnormalities in children born to diabetic pregnancies [17]. Carlos-Hiceta et al. suggested that maternal hyperglycemia may be a potential risk factor for congenital hearing impairment [19]. These findings collectively suggest early cochlear dysfunction in neonates exposed to intrauterine metabolic stress.

Follow-up OAE Outcomes and Reversibility

On repeat OAE testing, referral rates reduced in both groups but remained significantly higher in the GDM group ($p = 0.02$). This indicates that while some abnormalities may be transient, a subset of neonates may exhibit persistent cochlear dysfunction.

Similar patterns of initial failure followed by normalization have been reported in Indian hospital-based studies [16,18]. International literature also indicates that early OAE abnormalities may resolve, particularly when associated with transient middle ear factors [17].

BERA Referral and Neural Involvement

Neonates with persistent "refer" results were referred for BERA, and referral rates were significantly higher in the GDM group ($p = 0.04$).

While OAE assesses outer hair cell integrity, BERA evaluates neural conduction along the auditory pathway. Grimmer et al. demonstrated auditory brainstem response alterations in infants of diabetic mothers [20]. Similarly, deRegnier et al. reported delayed auditory maturation in neonates born to diabetic mothers [21]. These findings suggest that in addition to cochlear involvement, neural conduction abnormalities may also occur in this high-risk population.

Pathophysiological Correlation

The association between gestational diabetes mellitus and neonatal hearing dysfunction can be explained through several mechanisms. Maternal hyperglycemia leads to fetal hyperglycemia and hyperinsulinemia, increasing fetal metabolic demand and predisposing to intrauterine hypoxia. Langer et al. highlighted the adverse impact of poor glycemic control on fetal outcomes [18].

Experimental studies provide biological plausibility. Makishima and Tanaka demonstrated pathological changes in the inner ear in diabetic conditions [22]. Brownlee described oxidative stress and microangiopathy as central mechanisms in diabetic complications [23]. Similar microvascular compromise in the cochlea may impair outer hair cell function, resulting in abnormal OAE findings.

Comparison with Conflicting Literature

Not all studies demonstrate permanent hearing loss in neonates of diabetic mothers. Some investigations report normal ABR findings when glycemic control is adequate [17, 20]. This suggests that the severity and persistence of maternal hyperglycemia may be more important determinants than GDM diagnosis alone. Differences in screening timing, methodology, and follow-up duration may also account for variability across studies.

Clinical Implications

The findings of the present study highlight that neonates born to mothers with gestational diabetes mellitus represent a high-risk group for early cochlear dysfunction. Even when permanent hearing loss is not confirmed, higher OAE referral and BERA evaluation rates indicate increased auditory vulnerability. In settings where universal newborn hearing screening is not uniformly implemented, infants of diabetic mothers should be prioritized for structured audiological follow-up.

CONCLUSION

The results of this study indicate that there is a statistically significant correlation between gestational diabetes mellitus and the abnormal outcome of neonatal hearing screening, especially at the scale of the cochlear functioning based on the results of TEOAE. Newborns whose mothers had GDM had markedly high initial and repeat OAE referral rates than newborns who were the babies of non-diabetic mothers.

Even though certain abnormal OAE results were resolved on retesting- which suggests that it may cause short-lived dysfunction within the cochlear apparatus- the continued occurrence of abnormal results in a proportion of neonates demonstrates the possibility of effects of intrauterine metabolic disruptions on fetal auditory development. The research confirms the idea that high maternal glycemia can negatively impact on the integrity of the cochlea via biological mechanisms that include hypoxia, microvascular fluctuations, and oxidative stress.

Although the cross-sectional design does not confirm the cause-effect relationship, the observed correlation highlights the need to focus on infants whose mothers are exposed to gestational diabetes as a high-risk population with respect to early auditory dysfunction. In this population, specific hearing screening and follow-up should be used especially where newborn hearing screening is not universally applied.

In addition, the findings support the significance of ideal glycemic regulation in pregnancy not only to avoid obstetric events but also to protect neuro-sensory fetal growth.

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