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REVIEW ARTICLE

Noise Pollution; The Silent Threat for Materno-Fetal Health: A Narrative Review

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ABSTRACT

Noise exposure was linked to any adverse health issues. The impact of noise on pregnancy and fetal outcomes was also reported. However, the reported evidence was inconsistent, and many times they were contradictory. Four electronic databases were searched for this review following the keywords (noise, environmental, occupational, maternal adverse effects, fetal adverse effects, preeclampsia, low-birth weight, preterm labor, gestational diabetes, gestational hypertension, and stillbirth). Inclusion criteria were studies published in English for the last ten years. Analysis showed wide diverse heterogeneity in the result and the significance level, and no firm conclusion can be reached. Many factors could have led to this discrepancy: inconsistent gestational age, non-standardized noise threshold and exposure time, and many co-variants. The current review highlights an important and overlooked subject that is vitally essential to raise awareness about. The topic interests pregnant and health policy to make informed decisions for the environment and update local health regulations.

Key words: Noise; Maternal Health; Fetal Health.

INTRODUCTION

Pollution is a worldwide problem for air, water, or noise. Noise is defined as any sound that disturbs the environment, whether unpleasant or excessive [1]. Noise exposure was linked to several public health problems, including stress, depression, heart and vascular disease, and cognitive and mental health illness [2, 3]. Noise adverse effects had expanded to include vulnerable pregnant and in-utero babies. Noise pollution can be caused by a variety of sources, as illustrated in **Table 1**. While often underestimated, it is a prevalent consequence of modern life [1]. Moreover, the threshold that defines noise is not unified across the literature, as shown in **Table 2**.

The global incidence of noise is rising; in America, many members of the general population are exposed to high noise levels. likewise, in Europe, the level of noise they are exposed to exceeds 55dB. The situation in Asia and Africa is similar, especially in urban areas. It is estimated that over 500 million people are exposed to noise, which urges real measures to halt the impact of noise on the general population and pregnant women in particular [9]. A great body of research has linked noise exposure to profound feto-maternal outcomes such as preeclampsia (PE), preterm labor (PL), low birth weight (LBW), gestational diabetes (GDM), and stillbirth [10]. The pathophysiological pathways that explain such association are complicated and may include the involvement of more than one, such as stress, endothelial dysfunction, and hormonal and autonomic dysregulation [11]. The available studies that address the impact of noise on pregnancy are limited, and some of them have presented inconsistent and sometimes contradicting evidence [7, 9, 12]. Not to mention the effect of confounders and co-variants, particularly air and chemical pollution. This underscores the need for more study in the field and the implementation of guidelines and recommendations for protecting feto-maternal welfare. A deeper insight into the multi-faceted nature of noise on fetal-maternal outcomes is vital to lay realistic and effective protective approaches [13]. This review seeks to explore different types of noise pollution, dive into the underlying mechanism by which it impacts the birth outcome, discuss and evaluate the available evidence, and highlight areas of further research to address this challenging and overlooked health problem.

METHODOLOGY

Research methods

Four electronic databases, Google Schooler, EMBASE, MEDLINE, and WOS, were reviewed using the keyword. We included studies published in the last decade in the English language that have the same aim (noise, environmental, occupational, maternal adverse effects, fetal adverse effects, PE, LBW, PL, GDM, GHT, and stillbirth). Exclusion was made to studies that were published outside the time limit and for those that were published in non-English. The SPIDER framework was followed: The sample of interest was pregnant, the phenomenon of interest was noise exposure, designs of the included studies, evaluating the feto-maternal outcome, and the type of the research [14].

Definition of study parameters

Preterm labor is the delivery of a fetus before completed thirty-seven weeks of gestation. It is a significant contributor to perinatal morbidity and mortality [15]. As for low-birth-weight LBW, it is defined as a fetal weight that is below two thousand and five hundred grams regardless of the fetal age [16]. LBW infants suffer from higher rates of adverse neonatal outcomes, reduced educational and academic performance, and higher rates of metabolic adult diseases [17, 18]. Hypertensive diseases of pregnancy (Gestational hypertension and more severe preeclampsia) were linked to increased adverse maternal morbidity and mortality [19]. As for the newborns, they are at major risk for iatrogenic prematurity, LBW, and SGA fetuses. Gestational diabetes is a form of glucose intolerance and IR that is diagnosed for the first time during pregnancy and is associated with many inverse feto-maternal outcomes such as macrosomia, PL, increased operative delivery and higher odds of neonatal complications [20]. Birth defects or congenital malformations are a group of abnormalities that affect the developing fetus, whether structural or functional and are diagnosed upon birth [21].

AUDITORY CHANGES FOR PREGNANTS AND GROWING EMBRYOS DURING PREGNANCY

i. **Pregnant auditory changes**

It is well known that the female body undergoes major changes due to pregnancy hormones, many pregnant women report an increased sensitivity to sounds and a change in their perception of sound, especially loud sounds and noise [22]. This can be attributed to hormonal effects, fluid retention and increased blood supply, which makes

Table 1. Types and sources of noise, with defining characteristics and impact

Type of Noise Exposure	Noise Source	Noise Character	Impact	References
Traffic Noise	Road traffic, railway, & Aircraft	Continuous & persistent, especially in urban areas.	Stress, sleep disturbance, & cardiovascular complications.	[4]
Industrial Noise	Factories, manufacturing areas, & construction workplaces	High levels with diverse frequencies.	Chronic exposure causes hearing loss and other health problems.	[5]
Occupational Noise	Workplaces where heavy machinery or equipment are used	Exposure relies on the industry type & job role. Working personnel needs hearing protection equipment & noise assessment protocol.	Chronic exposure is a major cause of noise-related hearing loss.	[6]

Table 2. Highlights the discrepancy in the available noise threshold and the regulations surrounding them.

Region /or Organization	Noise Threshold Regulations	References
World Health Organization	It is recommended that the average noise levels not exceed 53 dB for RTN during the daytime and 45 dB during the night-time to reduce the health effects.	[7]
United States	Permissible exposure limits for workplace noise at 90 dB over an eight-hour workday. The community noise levels were set at < 70 dB over 24 hours.	[8]
European Union	Typical urban noise levels are 55 dB (day-time) and 50 dB (night-time).	[9]
Asia and Other Regions	Noise regulations are diverse, and many of them follow WHO guidelines. Rapid urbanization has raised concerns about RTN & industrial noise.	[7]

the eardrum swollen and sensitive to sound.

ii. **Fetus auditory changes**

The fetus's auditory system during the second trimester is still not mature enough to respond to all sounds. By the 25-30th weeks, the auditory system is functionally mature enough to respond to all sounds, and this is the critical period in which a baby can be vulnerable to all acoustic stimuli and noise effects [23]. Some concerns were raised that prolonged exposure to noise during this time lag may trigger hearing loss in the neonate [24].

RESULTS OF LITERATURE REVIEW

Studies published in the last decade are summarized in **Table 3**. The strength of evidence behind those studies seems inconsistent and sometimes insignificant. For example, LBW risk was linked to noise [12, 25], while the evidence was very low in Nieuwenhuijsen et al. study [7]. Those results contradict Hohmann et al. [11], who declared that it had no effect. For PL risk, Nieuwenhuijsen [7] declared low-quality evidence, while no meaningful effect was found by Dzhambov [10] and Hohmann et al.[11].

For gestational hypertension, Dzhambov et al. [10] showed significant risk which contradicts Wang Z et al. [26], which confirms no associations. The odds for PE were higher for those exposed to noise, according to Wang Z et al. [26], while Dzhambov et al. [10] deny any associations. Wang Z et al. [26] the study excluded any association with GDM risk. Congenial malformation risk was found to be significant in Dzhambov et al. [10] while both Vincent [27] and Nieuwenhuijsen [7], found small evidence of increased risk.

Small for gestational age fetuses was significantly high among Dzhambov et al [10]. conversely, Dzhambov [12] found no significant risks. In summary, the evidence of association is quite diverse and mixed across different studies and outcomes.

THE MECHANISM THAT UNDERLIES NOISE AND ADVERSE FETO-MATERNAL OUTCOMES

The most proposed theories that explained the association between noise exposure and adverse feto-maternal outcomes were summarized in Figure 1. A detailed explanation of each includes:

i. Stress theory: maternal exposure to noise triggers stress hormones, which in the longterm increase pregnant odds of PE and PL [28].

ii. Endothelial dysfunction: chronic exposure to noise triggers vascular changes and endothelial dysfunction (key elements in PE, FGR, LBW), which will hinder placental function and cause fetal hypoxia added to compensatory maternal hypertension [29].

iii. Oxidative stress and inflammation theory: noise exposure triggers inflammation and creates oxidative stress where a vicious circle of distraction occur in the maternal body, a typical situation in GDM and PL [30].

iv. Disbalances between the sympathetic and parasympathetic systems and noise exposure will cause autonomic dysregulation, which may trigger PE and PL [31].

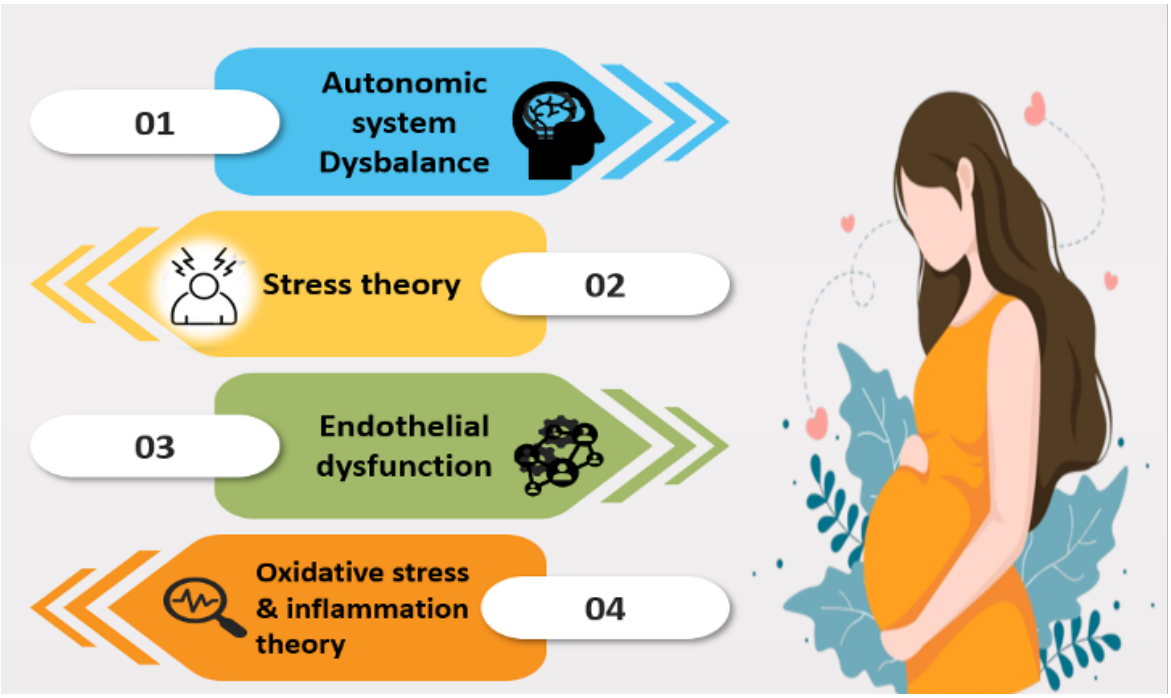

Figure 1. The theorize that explained adverse maternal and fetal outcomes to chronic noise exposure.

Table 3. The main studies included in the analysis with major points of interest highlighted

Authors, Year	Study Type and Numbers Included Parameters Tested	Main Study Results	References
Hohmann et al. 2013	Systemic review that included 12 studies. To examine the impact of chronic noise on PL, LBW, fetal death, and congenital malformation	There is no association. They postulated that the high level of variation and heterogeneity could be the reason for an insignificant result.	[11]
Ristovska, G 2014	Systemic review that included nine studies, mostly aircraft noise at 80 dB	Their results showed suggestive associations with noise, especially for LBW.	[25]
Dzhambov et al. 2014	Systemic review & meta-analysis of 28 studies	Meaningful risk for small for gestational age fetus, GHT, and higher congenital malformation. NO statistically significant for PL, PE, abortion & death.	[10]
Nieuwenhuijsen MJ 2014	Systemic review & meta-analysis that included 14 studies that looked into different kinds of noise: aircraft noise, road traffic noise, & total ambient noise	Very low-quality associations between aircraft noise & PL, LBW, and congenital anomalies. Low-quality evidence for an association between road traffic noise & LOW, PL, & SGA.	[7]
Dzhambov 2019	Systemic review & meta-analysis that included nine studies. They tested road noise with LBW, SGA, and PL.	They discussed that there is an 8.27 g reduction in birth weight with a 10 dB noise level. No significant effects for SGA or PL.	[12]
Wang Z eta 2022	Meta-analysis: 11 studies included. The study examined occupational and residential noise effects on maternal address effects.	Exposure to occupational noise caused higher PE odds by 1.12. No association was proved with GHT or GDM.	[26]
Vincens N 2023	Scoping review of 16 studies discussed the effect of noise on congenital anomalies, congenital hearing loss, & perinatal mortality.	A small increase in congenital malformation with noise exposure, no consensus regarding perinatal mortality and stillbirth. A possible link between congenital hearing loss and noise.	[27]

DISCUSSION

Although studies examining the effect of noise have exponentially increased, many issues are raised upon reviewing them. Not all of them standardized the exposure; some examined occupational noise, others examined environmental noise, and others examined both [32].

A retrospective study was the main study type included, with the potential limitation of misreporting. Small sample studies were another issue that hindered earlier publication. Not all the studies used the same cut-off value for noise (75-80dB). The level of noise set for most of these studies is fixed for normal people and not customized for pregnant [31]. Another important point is exposure time, which shows a wide discrepancy between environmental and occupational [33]. One of the major issues of noise effect is the presence of co-factors, combined occupational and environmental, which may have synergistic effects on the mother. Not to mention the presence of other sources of pollution, such as air and chemical pollution [34]. Accessing restorative places such as parks and blue areas tends to soothe stress, a major contributor to the noise effect on the mother and her growing child [35]. In light of increased public awareness of noise's impact on health, many preventive interventions have emerged to reduce noise adverse effects among the population added as personal protection devices to protect against noise-related hearing deficiency, which effectively reduced hearing loss; however, other health-related problems such as cardiovascular and psychological effects were not reduced [36]. In pregnancy, while personal protective hearing devices protect the mother, they are unable to safeguard the fetus since these sound waves can easily penetrate the abdomen [37]. Many co-varients were suggested for the impact of noise pollution on both feto-maternal health, such as dose and the time of exposure, added to the types of noise they are exposed to [38]. Some proposed that growing fetuses are especially suspectable to low-frequency sound waves rather than high frequency, especially when the fetus is in the third trimester [37, 38]. Another interesting area of research is the role of exogenous antioxidants in mitigating noise-associated adverse effects [39]. Animal studies showed optimistic results with administrating antioxidant minerals and vitamins; this topic deserves further research to optimize prophylactic and therapeutic interventions [40, 41]. A handful of Iraqi studies addressed noise's impact on the population (but not among pregnant), discussing noise's association with hearing loss, its effects on quality of life, and its role as an occupational hazard, and some suggested protective solutions to reduce noise impact on the public health [42–45].

The strength of this review lies in its systematic discussion and analysis of evidence behind noise impact on reproductive health using recently published meta-analyses. These are important for pregnant individuals as they show potential risks often overlooked and underappreciated. This enables them to make informed decisions regarding the environment they live in. Our results may guide pregnant individuals to take precautions to minimize acoustic risk. They may guide political -health agencies to increase public awareness to promote and optimize feto-maternal outcomes.

Regarding the study limitation, Many confounders and heterogeneity in the included studies prevented the implementation of firm recommendations. Indeed, the controversy warrants further long prospective studies with standardized parameters to reach firm conclusions and recommendations.

CONCLUSIONS

Although the evidence of noise exposure and maternal and feto-maternal outcomes conflicted, the topic is vital to address. Raising public awareness, updating local regulations for noise, and conducting longitudinal studies to confirm the impact on Iraqi pregnancy are all recommended areas of research.

ETHICAL DECLARATIONS

- **Acknowledgements**

  None.

- **Ethics Approval and Consent to Participate**

  Not required.

- **Consent for Publication**

  Not applicable.

- **Availability of Data and Material**

  No patient data are presented in the study.

- **Competing Interests**

  The authors declare that there is no conflict of interest.

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- **Authors' Contributions**

All stated authors contributed significantly, directly, and intellectually to the work and consented it to be published.

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