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The Triadic Lifeline: The Placenta as a Vital Interface Between Mother, Fetus, and the Environment in the Derna City

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الحبل الحيوي الثلاثي: المشيمة بوصفها واجهة حيوية بين الأم والجنين والبيئة في مدينة درنة

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ABSTRACT: The placenta is a multifunctional organ that plays a central role in maternal adaptation, fetal growth, and neonatal health. In addition to regulating the exchange of oxygen, nutrients, and metabolic waste, it contributes to endocrine signaling and immune regulation. Placental characteristics and pregnancy outcomes are influenced by a range of potential maternal, obstetric, and environmental factors, with important implications for neonatal and pediatric care. This study examines delivery patterns, newborn birth weight, and placental weight using a combined dataset that includes monthly birth statistics over nine months and detailed clinical records from nine maternal-newborn cases. The analysis focuses on the distribution of delivery methods, birth-weight classification, and placental morphological measurements. The available data include 1,737 births in the overall dataset (derived from the monthly records), although minor discrepancies between monthly records and listed totals require verification. Among the eight newborns whose weights were recorded, six (75.0%) had birth weights of at least 2.5 kg, while two (25.0%) had low birth weight. Placental weights in the nine clinical cases ranged from 0.506 to 0.776 kg, with a reported mean of 0.653 kg. The findings provide a preliminary descriptive overview of obstetric and neonatal outcomes and demonstrate the potential value of integrating obstetric and pediatric information with placental assessment. However, the small clinical sample, incomplete records, and absence of measured environmental-exposure data limit causal interpretation. Further studies integrating standardized placental examination, detailed neonatal follow-up, and environmental-exposure assessment are warranted.

Keywords: placenta; maternal–fetal interface; placental weight; birth weight; birth outcomes; neonatal health; environmental health; child growth.

الملخص:

المشيمة عضو متعدد الوظائف يؤدي دوراً محورياً في تكيّف الأم ونمو الجنين وصحة المولود. فإلى جانب تنظيمها تبادل الأكسجين والمغذيات والفضلات الأيضية، تسهم في الإشارات الهرمونية والتنظيم المناعي. وتتأثر خصائص المشيمة ونتائج الحمل بمجموعة من العوامل الأمومية والتوليدية والبيئية المحتملة، مع انعكاسات مهمة على رعاية حديثي الولادة والأطفال. تتناول هذه الدراسة أنماط الولادة ووزن المولود عند الولادة ووزن المشيمة باستخدام مجموعة بيانات مجمّعة تشمل إحصاءات الولادات الشهرية على مدى تسعة أشهر وسجلات سريرية

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تفصيلية لتسع حالات أم–مولود. ويركّز التحليل على توزيع طرق الولادة وتصنيف وزن المولود والقياسات الشكلية للمشيمة. وتشمل البيانات المتاحة 1,737 ولادة في مجموعة البيانات الإجمالية (محسوبة من السجلات الشهرية)، مع أن تباينات طفيفة بين السجلات الشهرية والمجاميع المدرجة تتطلب التحقق. ومن بين المواليد الثمانية الذين سُجّلت أوزانهم، كان وزن ستة منهم (75.0%) 2.5 كغم فأكثر، بينما كان اثنان (25.0%) منخفضي الوزن عند الولادة. وتراوحت أوزان المشيمة في الحالات السريرية التسع بين 0.506 و0.776 كغم، بمتوسط مُبلَّغ عنه قدره 0.653 كغم. وتقدّم النتائج لمحة وصفية أولية عن النتائج التوليدية ونتائج حديثي الولادة، وتُبرز القيمة المحتملة لدمج المعلومات التوليدية ومعلومات طب الأطفال مع تقييم المشيمة. غير أن صغر العينة السريرية ونقص السجلات وغياب بيانات مقيسة عن التعرض البيئي تحدّ من إمكانية التفسير السببي. وتبرز الحاجة إلى دراسات أخرى تدمج الفحص المعياري للمشيمة والمتابعة التفصيلية لحديثي الولادة وتقييم التعرض البيئي.

الكلمات المفتاحية: المشيمة؛ الواجهة بين الأم والجنين؛ وزن المشيمة؛ وزن الولادة؛ نتائج الولادة؛ صحة حديثي الولادة؛ الصحة البيئية؛ نمو الطفل.

1. INTRODUCTION

The placenta is a temporary but essential organ that supports pregnancy by regulating the exchange of oxygen, nutrients, and metabolic waste between the maternal and fetal circulations. It also produces hormones, participates in immune regulation, and helps maintain a suitable intrauterine environment. Its functions extend beyond passive transport, making it an active regulator of maternal adaptation and fetal development. However, this vital organ faces serious environmental and health challenges after delivery. This study highlights a proposed "pollution biofeedback loop," in which improper disposal of discarded placentas through open burning in Derna introduces harmful substances and toxic gases that may exceed the local environment's capacity to absorb them (air and soil). These pollutants may then adversely affect maternal and fetal health through inhalation of emissions, potentially endangering fetal development and creating cumulative health risks across successive generations (Beaumont et al., 2023; Ghazi, Naidoo, Naidoo, & Chuturgoon, 2021; Gundacker & Hengstschläger, 2012).

Research Problem

This study focuses on unsafe field practices and environmental pollution resulting from improper and indiscriminate disposal of biomedical waste (Sawalem, Selic, & Herbell, 2009). The problem is reflected in the following points:

- **Critical field situation in Derna:** transporting and collecting placentas after deliveries without complying with personal protective equipment (PPE) requirements and appropriate protocols, such as protective gloves and designated hazardous-waste bags/containers.
- **Environmental pollution from open burning:** disposing of these placentas through uncontrolled open-air burning in the Al-Dhahr Al-Ahmar area of Derna, resulting in the release of harmful gases and pollutants that contaminate the surrounding air, soil, and nearby communities.
- **Direct threat to maternal and child health:** the placenta which serves as a vital biological link that protects and nourishes the fetus becomes a source of secondary environmental pollution, exposing the health of mothers, fetuses, and the community to risks of infection and environmental toxic exposure.

Accordingly, the main research problem is formulated in the following research question:

> "What is the effect of environmental pollution resulting from unsafe disposal and open burning of placentas in the Al-Dhahr Al-Ahmar area of Derna on maternal and child health and the surrounding environment?"

Significance of the Study:

This study is significant because it addresses a sensitive environmental and health issue involving one of the most biologically important structures, the placenta and the effects of its disposal method on the environment and public health. Its significance is reflected in the following points:

Theoretical (scientific) significance:

- **Addressing the research gap:** enriching scientific and academic literature with environmental and applied studies linking maternal and fetal safety to exposure to environmental pollutants generated by medical waste.
- **Highlighting the placenta's dual role:** providing a deeper understanding of the placenta not only as a vital organ that transfers nutrients and oxygen to the fetus, but also as an environmental medium that may retain and be affected by traces of pollution.

Practical (field and applied) significance:

- **Protecting maternal and fetal health:** raising awareness of health and biological risks arising from exposure to pollutants generated by the burning and unsafe disposal of medical waste.1
- **Highlighting field conditions:** documenting environmental risks resulting from indiscriminate disposal and open burning of biological waste in open areas, such as Al-Dhahr Al-Ahmar in Derna.
- **Supporting decisionmakers and health authorities:** providing a database and scientific proposals to help health and environmental institutions establish strict protocols for the collection, treatment, and safe disposal of medical waste.

The environmental impact is intensified by transporting this biomedical waste and openly burning it in the Al-Dhahr Al-Ahmar area of Derna. Open burning that is not controlled by standard medical-incinerator safeguards can release gaseous pollutants and hazardous compounds that contaminate the surrounding air and soil (Diaz, Savage, & Eggerth, 2005). In addition, it may expose workers involved in the process and nearby communities to bacterial and viral contamination and cross-infection risks.

Accordingly, this field context highlights the importance of studying "environmental exposure" as a central link. A placenta that has accumulated environmental toxicants and affected fetal health in utero may, in turn, become part of a new pollution cycle when disposed of indiscriminately. This underscores the need for strict medical-waste management protocols to protect maternal and child health and the surrounding environment.

The placenta develops within the maternal environment and may be affected by maternal health, nutritional status, lifestyle, and exposure to environmental pollutants. Factors such as air pollution and selected chemical exposures have been investigated for their potential effects on placental function, fetal growth, and pregnancy outcomes (Dejmek, Selevan, Benes, Solansky, & Sram, 1999; Erickson & Arbour, 2014; Kannan, Misra, Dvonch, & Krishnakumar, 2006; van den Hooven et al., 2012). The strength and clinical significance of these associations vary according to the exposure, timing, intensity, and characteristics of the maternal–fetal unit (Bonzini et al., 2010; Gundacker & Hengstschläger, 2012; Shah & Balkhair, 2011).

The clinical importance of placental health extends beyond delivery. Adverse intrauterine conditions may be associated with preterm birth, low birth weight, and altered fetal growth (Salafia, Charles, & Maas, 2006). These outcomes matter to neonatologists and pediatricians because of their potential implications for later growth and neurodevelopment. However, these associations should be interpreted in light of the available evidence and the effects of other maternal, genetic, social, and environmental factors.

Understanding the placenta therefore requires a multidisciplinary perspective integrating obstetrics and gynecology, pediatrics, environmental health, and geography. Such an approach may help connect maternal and obstetric characteristics with neonatal outcomes, while recognizing that geographic and environmental effects must be evaluated using appropriate exposure data.

In clinical practice, placental weight and morphology may provide additional information about the intrauterine environment (Lao & Wong, 1996). However, placental weight alone cannot establish placental dysfunction or explain an individual neonatal outcome. Interpretation requires consideration of gestational age, maternal characteristics, fetal growth, pregnancy complications, and relevant placental findings (Beaumont et al., 2023).

The present study combines overall birth statistics with detailed maternal and newborn records, including placental-weight measurements. By describing delivery patterns, newborn birth weight, and placental characteristics, it seeks to establish a preliminary clinical and epidemiological basis for multidisciplinary maternal and child health research.

Study Objectives:

1. To investigate the environmental pollution risks associated with indiscriminate disposal and open-air burning of placentas.
2. To assess the effects of this pollution on maternal health, fetal health, and the surrounding environment.

Research Hypotheses:

1. Indiscriminate disposal of placentas causes environmental pollution that poses a direct threat to the local environment.
2. An association exists between the spread of environmental pollution and increased health risks affecting the safety of both mothers and fetuses.

2. LITERATURE REVIEW

Study Terms:

- **Placenta:** a temporary biological organ that forms the vital link between mother and fetus for nutrient and oxygen transfer; in this study, it is also considered biomedical waste whose disposal effects are examined.
- **Maternal and child health:** the physical and health well-being of the mother and fetus/child, and their protection from environmental hazards, diseases, and pollutants.
- **Environmental pollution:** an adverse disturbance in environmental components (air and soil) caused by introducing harmful substances or toxins beyond nature's capacity to absorb them.

Concept of Environmental Pollution:

> "Environmental pollution is any adverse change or sudden disturbance in the physical, chemical, or biological characteristics of the basic environmental components (air, water, and soil). It results from introducing harmful substances or excess energy (such as medical waste, chemicals, or radiation) at rates that exceed the natural environment's capacity for absorption or self-purification, thereby harming living organisms and ecosystems."

The study highlights a critical "pollution biofeedback loop," in which toxins released by open burning of discarded placentas in Derna contaminate the local environment and may return through maternal inhalation, potentially accumulating in future placentas and harming fetal development, creating a cumulative, multigenerational health risk.

- **Biomedical waste:** waste and tissues generated by healthcare (such as placentas) that carry a high risk of infection transmission and contamination.
- **Open burning:** disposal of waste by burning it outdoors without equipped medical incinerators, directly releasing toxins and harmful emissions.

Environmental Exposure and the Effects of Indiscriminate Disposal

Biomedical waste—especially the placenta, which represents a lifeline between mother and fetus—poses major environmental and health risks if it is not handled according to approved health standards and protocols (World Health Organization, 2014). In Derna, this environmental problem is reflected in unsafe field practices related to placental disposal after delivery. Placentas are transported and handled using rudimentary methods without basic personal protective equipment, such as protective gloves, bags, and medical containers designated exclusively for high-risk biological waste.

The Pollution Biofeedback Loop and Intensification of Environmental Impact

What gives this issue a particularly serious environmental and health dimension is what is referred to as the "pollution biofeedback loop." Unsafe disposal of placentas through open burning in Al-Dhahr Al-Ahmar releases gaseous emissions and toxin-laden fine particles into the air and soil. These pollutants may then be inhaled or absorbed by pregnant women living in nearby areas and communities.

This inhaled environmental pollution may travel through the maternal bloodstream and reach the placenta in current or future pregnancies. The placenta may then act as a biological barrier that absorbs and accumulates these toxicants, potentially exposing the fetus to serious health and developmental risks in utero. As a result, a closed environmental cycle is proposed: placentas burned and indiscriminately discarded today may, through their emissions, contribute to contamination affecting future placentas and fetuses. This could create a cumulative, multigenerational environmental risk in Derna.

3. METHODS

Study Design:

This study uses a descriptive observational approach based on two components: overall monthly birth statistics and individual clinical records for mothers and newborns. The overall dataset covers nine months of reporting, while the clinical component includes nine cases recorded with varying degrees of completeness.

Available records were reviewed descriptively to examine delivery patterns, newborn birth weight, and placental weight. Given the descriptive nature of the available data, the analysis does not establish causal relationships between maternal characteristics, placental measurements, and neonatal outcomes.

Data Sources and Study Population:

The dataset consisted of:

- **Overall birth records:** monthly counts of vaginal births and cesarean sections over nine months.
- **Clinical case records:** nine maternal-newborn cases containing selected maternal demographic and clinical variables, newborn characteristics, and placental-weight measurements.

The overall birth statistics and individual clinical cases represent separate analytical components. The available documents do not indicate whether the nine clinical cases were selected from the same population as the overall birth records.

Study Variables:

Variables extracted from the clinical records included:

- Maternal age.
- Maternal nationality and residence.
- Gravidity and parity.
- History of miscarriage.
- Preterm-birth status.
- Presence of uterine fibroids.
- Type of labor, including spontaneous or induced labor.
- Newborn sex.
- Newborn birth weight.
- Maternal blood group, where recorded.
- Placental weight.
- Umbilical-cord characteristics, where recorded.

The overall dataset also included monthly counts of vaginal births and cesarean sections.

Outcome Definitions:

- **Low birth weight (LBW):** birth weight below 2,500 g (2.5 kg), regardless of gestational age.
- **Birth weight of 2.5 kg or above:** a birth weight equal to or greater than 2.5 kg. This category should not be interpreted as a complete assessment of appropriate fetal growth, which requires consideration of gestational age and other clinical factors.
- **Placental weight:** placental weight recorded in kilograms and summarized using the available clinical measurements. The documents do not clarify whether all measurements were obtained using a standardized protocol or whether placentas were weighed before or after removal of the umbilical cord and membranes.
- **Mode of delivery:** vaginal birth or cesarean section, as recorded in the overall monthly dataset [8].

Statistical Analysis:

The analysis was primarily descriptive. Categorical variables were summarized using frequencies and percentages, while continuous variables were described using the available measures of central tendency and dispersion.

For newborn birth weight, the analysis was restricted to cases with recorded measurements. Placental weight was summarized using the reported minimum, maximum, mean, and standard deviation. Monthly birth counts were reviewed to describe the distribution of delivery methods.

Because the clinical sample included only nine cases and contained missing observations, inferential statistical testing and causal models were not considered appropriate based on the information currently available. The overall monthly totals also require reconciliation before final estimates of the overall cesarean-section rate can be reported.

4. RESULTS

4.1 Overall Birth Statistics

The monthly records give a total of 1,737 births over nine months, including 1,070 vaginal births and 667 cesarean sections. The corresponding overall proportions are 61.6% for vaginal birth and 38.4% for cesarean section.

Monthly records showed variation in the numbers for the two delivery methods. Monthly vaginal births ranged from 95 to 137, while cesarean sections ranged from 58 to 86.

An arithmetic review of the monthly records identified two minor discrepancies. The separately listed monthly-total column sums to 1,738, one more than the 1,737 births obtained by adding the delivery-method counts. In addition, the recorded delivery method counts for the first month sum to 202, while the listed total for that month is 203.

These discrepancies must be resolved against the original hospital records before the final overall birth counts and proportions are accepted.

Table 1 Summary of aggregate delivery statistics across nine reporting months

Delivery mode	Frequency (n)	Percentage (%)
Normal vaginal delivery	1,070	61.6
Cesarean section	667	38.4
Total	1,737	100.0

Note: Percentages are calculated from the summed mode-specific counts (n = 1,737). The original hospital registers should be checked before publication.

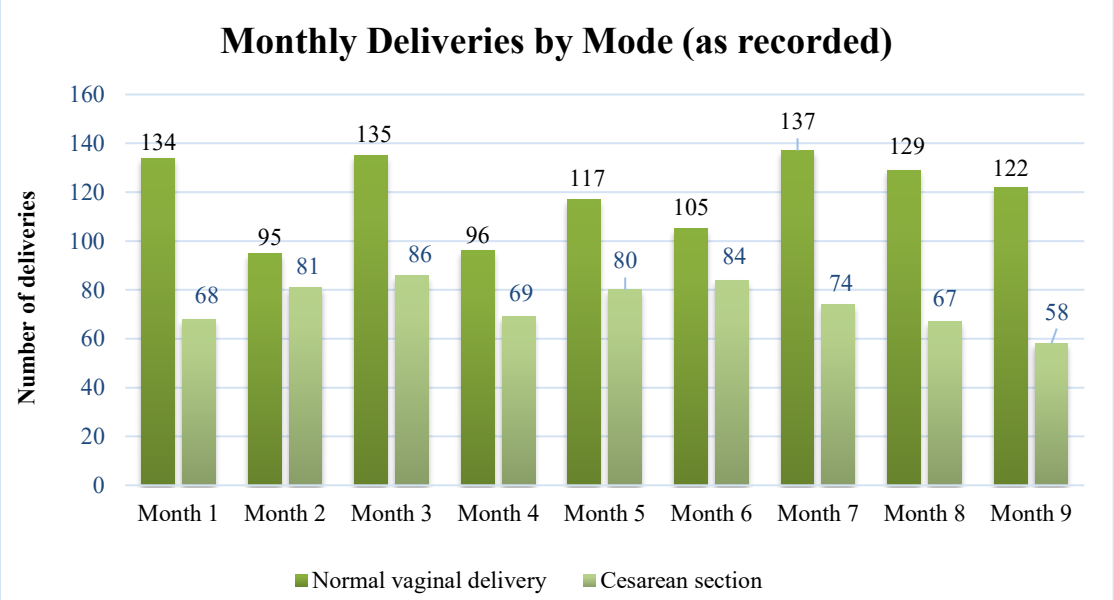

Fig. 1 Monthly distribution of vaginal births and cesarean sections according to the available records.

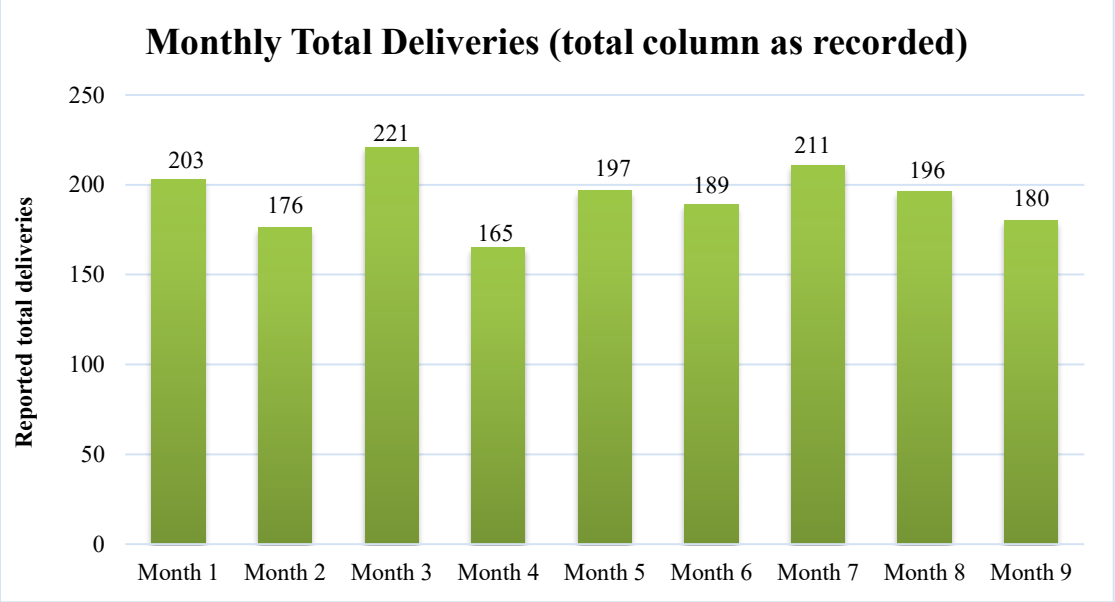

Fig. 2 Monthly total births as listed in the source total column; verification of consistency with the delivery method counts.

4.2 Classification of Newborn Birth Weight

Birth weight was available for eight of the nine clinical cases. Six newborns (75.0%) had recorded birth weights of at least 2.5 kg, while two (25.0%) weighed less than 2.5 kg and therefore met the definition of low birth weight.

The two low-birth-weight cases were:

- **Case 2:** birth weight of 2.075 kg, with maternal uterine fibroids recorded in the dataset.
- **Case 5:** birth weight of 2.115 kg, with preterm birth and induced labor recorded.

These observations describe the characteristics of two individual cases and do not establish that uterine fibroids or induced preterm labor caused the low birth weights. Interpretation is also limited by the lack of complete gestational-age information and other potentially relevant maternal and newborn variables.

One clinical case had no recorded birth weight and was therefore excluded from the birth-weight classification.

Table 2 Neonatal birth-weight classification

Birth-weight category	Frequency (n)	Percentage (%)
At least 2.5 kg	6	75.0
Low birth weight (<2.5 kg)	2	25.0
Total with recorded birth weight	8	100.0
Birth weight missing	1 of 9 cases	Not applicable

Note: Percentages are based only on the eight neonates with recorded birth weights. The missing measurement is excluded from the denominator.

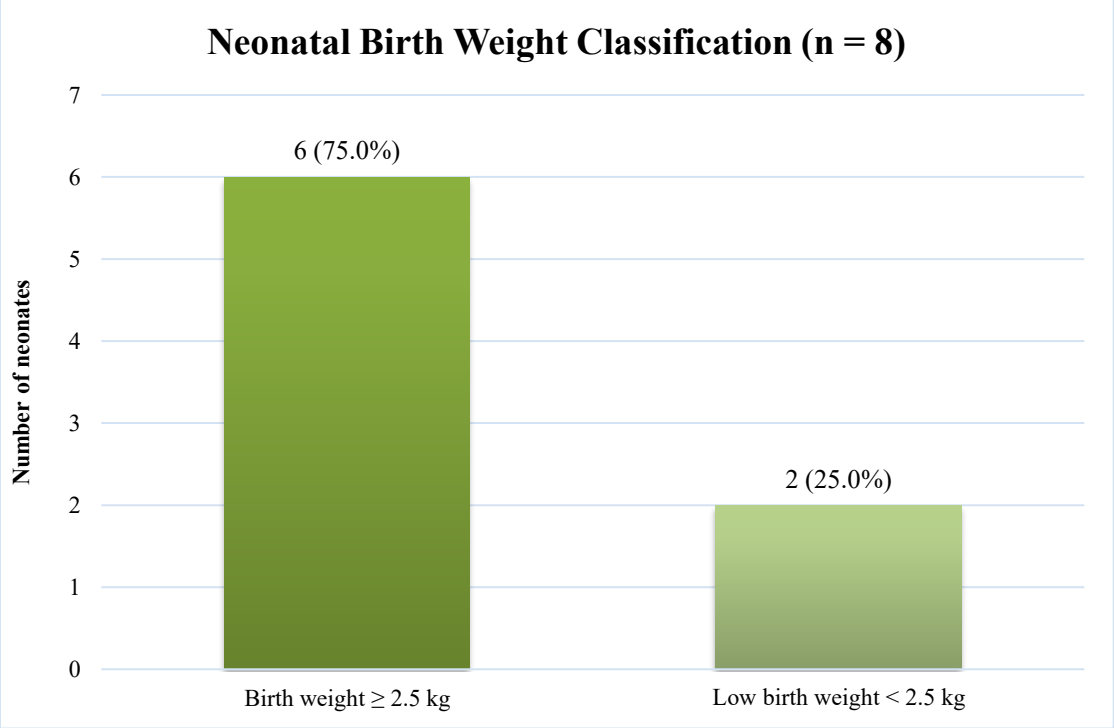

Fig. 3 Classification of newborn birth weights among the eight cases with available birth-weight measurements.

4.3 Placental-Weight Measurements

Placental weight was recorded for all nine clinical cases. Reported measurements ranged from 0.506 to 0.776 kg, with a mean of 0.653 kg and a standard deviation of 0.095 kg.

The lowest recorded placental weight was 0.506 kg in Case 5, whose record also documented preterm birth, induced labor, and a newborn birth weight of 2.115 kg. The highest recorded placental weight was 0.776 kg in Case 6, whose newborn's birth weight was 3.615 kg.

These individual observations suggest that placental and newborn measurements may be useful to examine together in future studies. However, the small sample size, limited gestational-age information, and absence of standardized placental morphology assessment prevent reliable conclusions about relationships between placental weight, fetal maturity, and birth outcomes.

Table 3 Descriptive statistics for placental weight

Statistic	Value
Number of cases	9
Minimum	0.506 kg
Maximum	0.776 kg
Mean	0.653 kg
Standard deviation (sample SD)	0.095 kg

Note: These are descriptive statistics from nine cases; interpretation is limited by the small sample and incomplete information on gestational age and weighing protocol.

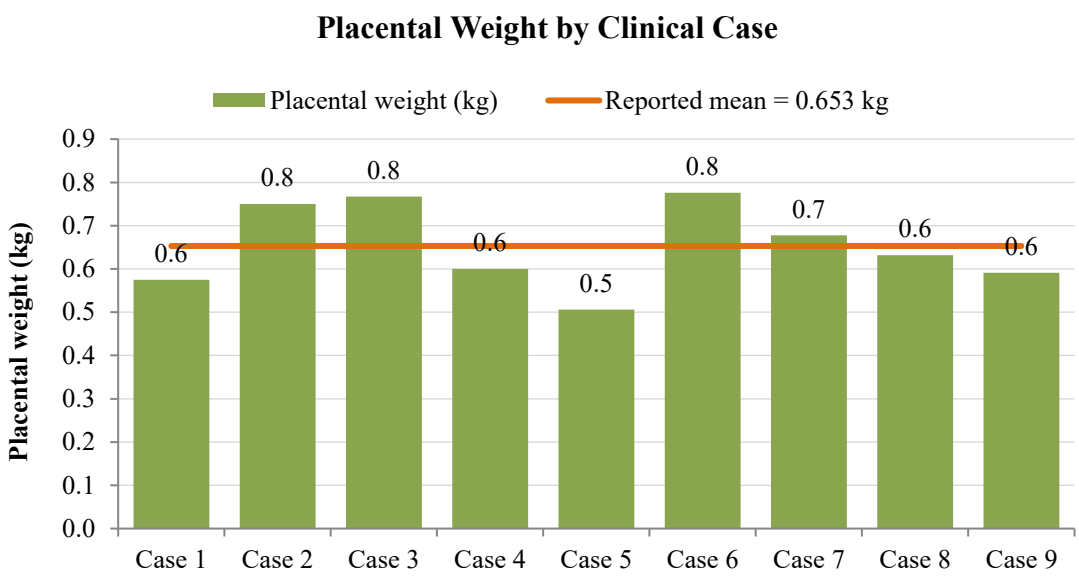

Fig. 4 Placental-weight measurements in the nine clinical cases; the dashed line indicates the reported mean of 0.653 kg.

4.4 Maternal and Obstetric Characteristics

The nine clinical records contained information on maternal age, nationality, residence, gravidity, parity, history of miscarriage, preterm-birth status, uterine fibroids, and type of labor. Newborn sex, maternal blood group, and umbilical-cord characteristics were also recorded for some cases.

Maternal ages ranged from 23 to 34 years. Several variables had missing observations, including residence, gravidity, parity, birth weight, blood group, and umbilical-cord characteristics.

Given the small number of cases and incomplete documentation, the dataset supports a descriptive presentation of recorded characteristics but does not support robust comparisons between maternal subgroups or reliable estimates of associations with placental and neonatal outcomes.

4.5 Environmental Exposure Data and Expected Outcomes

Based on the hypotheses, theoretical framework, and field context of the study, the following outcomes are expected to be investigated:

Field assessment and waste management outcomes:

- **Lack of preventive protocols:** field verification of compliance with personal safety and protective standards (such as thick gloves, specialized medical bags, and containers for hazardous biological waste) during handling and transport of placentas in healthcare facilities (World Health Organization, 2014).
- **Reliance on traditional disposal methods:** field verification of whether the practice relies on open-air burning in the Al-Dhahr Al-Ahmar area of Derna because of a lack of modern enclosed medical incinerators equipped with purification filters (World Health Organization, 2024).

Environmental impact outcomes:

- **Increased environmental pollution indicators:** measurement of emissions, toxic fine particulate matter (PM2.5 and PM10), and gases produced by incomplete burning of biological waste in the air of Al-Dhahr Al-Ahmar and neighboring areas (Beaumont et al., 2023).
- **Deterioration of soil physical and chemical properties:** examination of possible deposition of residues from burned waste and accumulation of organic matter and bacterial pollutants in soil near the disposal site (World Health Organization, 2024).

Health impact and biofeedback-loop outcomes:

- **Increased respiratory and infection risks:** investigation of possible health risks associated with exposure to open-burning smoke; the current dataset contains no local measurements demonstrating a statistically significant relationship between exposure and health symptoms (World Health Organization, 2024).

- **Testing the "biofeedback loop" hypothesis:** testing the hypothesis that environmental pollution resulting from indiscriminate placental disposal may adversely affect pregnant women and fetuses in subsequent pregnancies, creating a cumulative pollution cycle that affects maternal and child safety.

5. DISCUSSION

This descriptive study combined monthly birth statistics over nine months with detailed records of nine maternal–newborn cases. The monthly records give 1,737 births, of which 61.6% were vaginal births and 38.4% were cesarean sections, with monthly vaginal births ranging from 95 to 137 and cesarean sections from 58 to 86. Among the eight newborns with recorded birth weights, six (75.0%) weighed at least 2.5 kg and two (25.0%) had low birth weight. Placental weight ranged from 0.506 to 0.776 kg, with a mean of 0.653 kg and a standard deviation of 0.095 kg.

The two low-birth-weight cases had different recorded characteristics: maternal uterine fibroids in Case 2, and preterm birth with induced labor in Case 5. The lowest placental weight (0.506 kg) was recorded in Case 5, whereas the highest (0.776 kg) was recorded in Case 6, whose newborn weighed 3.615 kg. Placental weight is commonly examined together with birth weight, for example as the placental ratio, as a marker of placental function (Lao & Wong, 1996; Salafia et al., 2006), and these individual observations suggest that the two measurements may be worth studying together. The mean placental weight in this series is also of a similar magnitude to the mean of 0.635 kg reported in a large population-based cohort (van den Hooven et al., 2012), although the populations, gestational ages, and weighing procedures are not strictly comparable. With nine cases, however, these observations remain descriptive and do not allow conclusions about the relationships between placental weight, fetal maturity, and birth outcomes.

The central environmental hypothesis of this study, the proposed pollution biofeedback loop, could not be tested with the available data, because no measurements of air or soil pollutants and no individual exposure estimates for the mothers were available. The findings therefore neither support nor refute an association between open burning of placentas in Al-Dhahr Al-Ahmar and maternal or neonatal outcomes. Studies from other settings have examined associations between air pollution and birth outcomes or markers of placental growth and function (Bonzini et al., 2010; Shah & Balkhair, 2011; van den Hooven et al., 2012); such designs rely on measured or modeled exposure data, which are not yet available for Derna.

Several limitations should be considered. The clinical sample is very small, and several variables were incomplete, including residence, gravidity, parity, birth weight, blood group, and umbilical-cord characteristics. Complete gestational-age information was not available, placental weighing may not have followed a standardized protocol, and it is not clear whether the nine clinical cases were drawn from the same population as the overall birth records. In addition, minor arithmetic discrepancies in the monthly counts remain to be verified against the original hospital registers. For these reasons, no inferential testing was performed, and the results should be regarded as a preliminary descriptive basis rather than evidence of cause and effect.

Future studies should combine standardized placental examination, detailed neonatal follow-up, and measured environmental exposure data, including air-quality measurements (PM2.5 and PM10) and soil sampling near the disposal site, so that the hypotheses of this study can be tested directly.

6. CONCLUSION

In conclusion, this study highlights the critical intersection of biomedical-waste management, environmental pollution, and maternal and child health, with particular focus on challenges reported in Derna. Open-air burning and unsafe disposal of placentas in Al-Dhahr Al-Ahmar may create immediate environmental risks and health risks for healthcare workers and local communities and may contribute to a harmful "pollution biofeedback loop." This recurring pollution may threaten fetal growth and health across generations.

Addressing these challenges requires an urgent, multidisciplinary approach. Implementing strict waste-management protocols, adopting modern medical incinerators, and enforcing preventive safety standards are essential steps to protect public health and the environment for future generations.

Recommendations and Proposals:

Based on the study findings and the field context highlighting serious environmental and health risks, the study proposes the following practical recommendations and solutions:

- **Provision of protective equipment and designated biohazard bags:** require all healthcare personnel and workers involved in maternity care to fully comply with personal protective equipment (PPE) requirements—including heavy-duty gloves, specialized medical bags, and hazardous-waste containers—when handling and transporting placentas.
- **Immediate cessation of open burning:** completely prohibit uncontrolled open-air burning in the Al-Dhahr Al-Ahmar area of Derna because of the harmful gaseous emissions and severe air and soil pollution it causes.
- **Establishment of modern enclosed medical incinerators:** accelerate the procurement, installation, and operation of approved medical incinerators equipped with modern emission-control and purification systems to prevent toxins and pollutants from entering surrounding ecosystems and residential areas.
- **Adoption of a national biomedical-waste management protocol:** develop binding guidance and a regulatory framework for hospitals and health centers in Derna that defines scientifically safe procedures for collecting, storing, and disposing of biological tissues and medical waste.

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