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RESEARCH TITLE

Environmental Toxicity and Reproductive Health Disruption: Evaluating Miscarriages, Congenital Anomalies, and Perinatal Mortality in Gaza (2023–2026)

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Abstract

Background: The military escalation in Gaza since October 2023 precipitated an unprecedented humanitarian catastrophe characterized by healthcare infrastructure destruction, environmental contamination, and disruption of reproductive health services.

Objective: To evaluate the incidence and temporal trends of miscarriage, congenital anomalies, preterm birth, stillbirth, and perinatal mortality in Gaza (October 2023–June 2026), and examine their association with environmental toxicity and healthcare collapse.

Methods: A retrospective ecological analysis was conducted using secondary data from the Palestinian Ministry of Health, Palestinian Centre for Human Rights, UNRWA-WHO joint reports, and Health Information Centre statements (November 2025–June 2026). Pre-conflict baseline data (2019–2022) were used for comparison. Spatial analysis using Moran's I and Getis-Ord Gi statistics was performed. Sensitivity analyses assumed 10–30% underreporting.

Results: The miscarriage rate surged to 460 per 1,000 live births by April 2026 (baseline: 140/1,000), representing a threefold increase. Approximately 5,000 miscarriages were recorded in 2025. Congenital anomalies more than doubled: 322 cases in 2025 and 385 by spring 2026, dominated by cardiac (33%), neural tube (13%), and urological (18%) malformations. Stillbirth rates rose from 6.0 to 10.3 per 1,000 births; preterm deliveries increased by 52% (4,100 cases in 2025). Monthly live births declined by 67% (6,076 in November 2025 to 2,004 in April 2026). An estimated 6,600 intrauterine deaths occurred in 2025. Over 67% of pregnant women suffered severe anaemia. Spatial analysis identified North Gaza and Gaza City as significant hotspots.

Conclusion: Gaza is experiencing a catastrophic disruption of reproductive health driven by synergistic effects of environmental toxicity, healthcare collapse, malnutrition, and displacement. Immediate international intervention, environmental remediation, and longitudinal surveillance are imperative.

Key Words: Gaza Strip; environmental toxicity; reproductive health; miscarriage; congenital anomalies; perinatal mortality; armed conflict.

عنوان البحث

السُّمِّيَّة البيئية واضطرابات الصحة الإنجابية: تقييم حالات الإجهاض والتشوّهات الخِلقية ووفيات الفترة المحيطة بالولادة في غزة (2023–2026)

المستخلص

الخلفية: أدّى التصعيد العسكري في غزة منذ أكتوبر 2023 إلى كارثة إنسانية غير مسبوقة، اتسمت بتدمير البنية التحتية للرعاية الصحية، والتلوث البيئي، وتعطّل خدمات الصحة الإنجابية.

الهدف :تقييم معدلات الحدوث والاتجاهات الزمنية للإجهاض، والتشوّهات الخِلقية، والولادة المبكرة، والإملاص، ووفيات الفترة المحيطة بالولادة في غزة خلال المدة من أكتوبر 2023 إلى يونيو 2026، ودراسة ارتباطها بالسُّمِّيَّة البيئية وانهيار منظومة الرعاية الصحية.

المنهجية: أُجري تحليل بيئي استعادي باستخدام بيانات ثانوية مستمدة من وزارة الصحة الفلسطينية، والمركز الفلسطيني لحقوق الإنسان، والتقارير المشتركة الصادرة عن وكالة الأمم المتحدة لإغاثة وتشغيل اللاجئين الفلسطينيين (الأونروا) ومنظمة الصحة العالمية، بالإضافة إلى بيانات مركز المعلومات الصحية الصادرة خلال المدة من نوفمبر 2025 إلى يونيو 2026. واستُخدمت بيانات خط الأساس لما قبل النزاع (2019–2022) لأغراض المقارنة. كما أُجري تحليل مكاني باستخدام إحصائيَّي **Moran's I** و**Getis–Ord Gi**، ونُفِّذت تحليلات حساسية بافتراض وجود نقص في الإبلاغ تتراوح نسبته بين 10% و30%.

النتائج: ارتفع معدل الإجهاض إلى 460 حالة لكل 1,000 مولود حي بحلول أبريل 2026، مقارنةً بمعدل خط أساس بلغ 140 حالة لكل 1,000 مولود حي، وهو ما يمثل زيادة تزيد على ثلاثة أضعاف. وسُجّلت نحو 5,000 حالة إجهاض خلال عام 2025. كما زادت حالات التشوّهات الخِلقية إلى أكثر من الضعف، إذ سُجّلت 322 حالة في عام 2025، وارتفع العدد إلى 385 حالة بحلول ربيع 2026، وكانت أبرزها تشوّهات القلب (33%)، وعيوب الأنبوب العصبي (13%)، وتشوّهات الجهاز البولي (18%). وارتفع معدل الإملاص من 6.0 إلى 10.3 حالات لكل 1,000 ولادة، في حين زادت حالات الولادة المبكرة بنسبة 52%، مسجّلةً 4,100 حالة خلال عام 2025. وانخفض عدد المواليد الأحياء شهريًا بنسبة 67%، من 6,076 مولودًا في نوفمبر 2025 إلى 2,004 مواليد في أبريل 2026. كما قُدّر عدد حالات الوفاة داخل الرحم بنحو 6,600 حالة خلال عام 2025، وعانت أكثر من 67% من النساء الحوامل من فقر دم حاد. وحدّد التحليل المكاني شمال غزة ومدينة غزة بوصفهما منطقتين ذواتي تركّز مرتفع ودلالة إحصائية لهذه الحالات.

الخلاصة :يشهد قطاع غزة اضطرابًا كارثيًا في الصحة الإنجابية ناجمًا عن التأثيرات المتآزرة للسُّمِّيَّة البيئية، وانهيار منظومة الرعاية الصحية، وسوء التغذية، والنزوح. ويُعدّ التدخل الدولي الفوري، والمعالجة البيئية، وإنشاء نظام رصد طولي مستمر، إجراءات ضرورية وملحّة.

الكلمات المفتاحية: قطاع غزة؛ السُّمِّيَّة البيئية؛ الصحة الإنجابية؛ الإجهاض؛ التشوّهات الخِلقية؛ وفيات الفترة المحيطة بالولادة؛ النزاع المسلّح.

1 .INTRODUCTION

The Gaza Strip, a densely populated coastal enclave of 365 km² housing over 2.2 million inhabitants, has been subjected to military escalation of unprecedented scale since October 2023.[1] The ensuing conflict has resulted in widespread destruction of civilian infrastructure, including the healthcare network. By mid-2025, fewer than 40% of hospitals retained operational capacity, depriving the population of antenatal, intrapartum, and postnatal care.[2,3]

Armed conflicts generate distinctive environmental contamination profiles. The detonation of high-explosive munitions releases heavy metals (lead, mercury, cadmium), energetic compounds (TNT, RDX, perchlorate), polycyclic aromatic hydrocarbons, and dioxins into air, soil, and water.[4,5] The teratogenic potential of these substances is well established: prenatal heavy metal exposure increases risks of spontaneous abortion, intrauterine growth restriction, and congenital malformations.[6,7] Perchlorate compounds disrupt thyroid function critical for fetal development.[8] In Gaza specifically, destruction of water and sanitation infrastructure has compounded chemical exposure risks.[9]

Epidemiological evidence from prior conflict settings—Iraq (2003–2015), Vietnam (Agent Orange), former Yugoslavia—demonstrates elevated reproductive adverse outcomes in populations exposed to munitions-derived contaminants.[10–12] In Fallujah and Basra, congenital malformations correlated with elevated lead, mercury, and depleted uranium residues.[13,14] However, these effects manifested over 5–10 years. In Gaza, geographic confinement, bombardment intensity, and simultaneous blockade of nutritional and medical inputs have compressed teratogenic effects into an accelerated timeframe.

The functional collapse of Gaza's healthcare system represents a critical mediating factor. Over 67% of pregnant women now suffer severe anaemia,[15] independently elevating risks of miscarriage, preterm delivery, and maternal mortality. The absence of folic acid supplementation compounds neural tube defect risk in a setting already burdened by environmental teratogens.[16]

While the humanitarian toll has been extensively documented, systematic epidemiological evaluation of reproductive health outcomes during 2023–2026 remains critically limited in peer-reviewed literature.[17] Existing reports provide fragmented data not consolidated into unified analytical frameworks. This study addresses this gap by quantifying incidence and temporal trends of miscarriage, congenital anomalies, preterm birth, stillbirth, and perinatal mortality; comparing against pre-conflict baselines; examining associations with environmental contamination and healthcare collapse; and formulating evidence-based recommendations.

2 .METHODS

2.1 Study Design and Setting

A retrospective ecological design with secondary data synthesis was employed. Primary data collection was neither feasible nor ethically tenable during active conflict. The study relied on systematic compilation, cross-referencing, and analytical integration of pre-existing quantitative data from official governmental records, UN agency surveillance reports, and documented health authority statements.[18] The ecological design permits examination of population-level trends across temporal windows, accommodates aggregated institutional data, and aligns with epidemiological precedents in conflict settings.[19]

2.2 Study Period and Data Sources

The study covered October 2023 through June 2026, subdivided into: pre-conflict baseline (2019–2022), early escalation (October 2023–December 2024), mid-conflict (January–June 2025), late-conflict (July–December 2025), and post-escalation/ongoing crisis (January–June 2026).

Four primary data sources were utilised: (1) Palestinian Ministry of Health (MoH) Health Information Centre, including the Special Statistical Report on Fetal Attrition (April 2026)[20] and Annual Report on Congenital Anomalies (2026)[21]; (2) Palestinian Centre for Human Rights (PCHR) Humanitarian Situation Report (July 2025)[22]; (3) UNRWA-WHO Maternal and Child Health Monitoring Report (2025)[15]; and (4) UN agency reports (UNRWA, OCHA, UNEP, IPC).[23–25]

2.3 Outcome Variables

All outcomes were defined per WHO and ICD-11 criteria[26]: miscarriage (fetal loss <24 weeks), congenital anomaly (structural/functional abnormality at birth), preterm birth (<37 weeks), stillbirth (fetal death ≥28 weeks), intrauterine death (all gestational ages), perinatal mortality (stillbirths + early neonatal deaths), and low/abnormal birth weight (<2,500g).

2.4 Statistical and Spatial Analysis

Descriptive statistics (frequencies, rates, percentages) were calculated for all outcomes. Temporal trends were charted monthly and annually. Proportional changes were calculated as: % Change = [(Rate_conflict − Rate_baseline)/Rate_baseline] × 100.

Spatial analysis was conducted using QGIS 3.34. Cases were georeferenced to five governorates. Buffer zones (1, 3, 5 km) around documented strike clusters were generated. Global Moran's I assessed spatial autocorrelation; Getis-Ord Gi identified hotspots ($z > 1.96$, $p < 0.05$).[27]

2.5 Sensitivity Analysis

Three underreporting scenarios (10%, 20%, 30%) were modelled. Three alternative baseline periods (2019–2022, 2021–2022, 2022 only) were tested. Direction and significance of trends remained consistent across all scenarios.

2.6 Ethical Considerations

This study used exclusively secondary, aggregated, de-identified data from publicly available reports. No primary data collection involving human subjects occurred. The study adhered to the Declaration of Helsinki[28] and CIOMS guidelines.[29]

2.7 Limitations

Key limitations include: underreporting due to healthcare destruction; absence of individual-level biomarker data; ecological fallacy (population-level associations cannot infer individual causation); baseline comparability challenges; and inability to control for individual confounders. These are discussed in Section 4.

3 .RESULTS

3.1 Healthcare Infrastructure Collapse

Table 1 documents the catastrophic impact on maternal healthcare infrastructure. Functional hospitals declined from 34 (2022) to 8 (June 2026), a 76.5% reduction. ANC coverage fell from 95.1% to ~25%. Folic acid supplementation coverage dropped from ~88% to ~10%. Maternal anaemia prevalence exceeded 67%.[15],[21]

3.2 Decline in Live Births

Monthly live births plummeted from 6,076 (November 2025) to 2,004 (April 2026), a 67.1% decline within five months.[20] Annual births in 2025 totalled 48,500, yielding 49,180 neonates.[30] This decline reflects reduced conception, elevated pregnancy loss, and registration disruption.

3.3 Miscarriage Escalation

The miscarriage rate surged from a pre-war baseline of ~140/1,000 to 460/1,000 by April 2026 (↑228%).[20] Approximately 5,000 miscarriages (<24 weeks) were recorded in 2025.[30] PCHR documented 2,600 miscarriages among 17,000 pregnancies in H1 2025 (15.3%).[22] Projections for H1 2026 estimate a further 70.7% increase, with rates potentially exceeding 500/1,000 by June 2026.[20] Three phases were identifiable: initial surge (October 2023–March 2024, 200–250/1,000), sustained elevation (April 2024–December 2025, 300–380/1,000), and accelerated escalation (January–June 2026, 460+/1,000).

3.4 Congenital Anomalies

Table 2 presents congenital anomalies classified by ICD-11 organ system. Total documented cases: 67 (H1 2025, PCHR)[22], 322 (2025, MoH)[21], 315 (January 2026)[30], and 385 (spring 2026).[20] The overall rate increased from ~3.4/1,000 (baseline) to 6.6–8.0/1,000.(%135–94↑)

Cardiac malformations constituted the largest category (33–34%), consistent with heavy metal cardiotoxicity.[31] Neural tube defects (12–14%) exceeded global averages (5–7%), consistent with folic acid absence.[32] Urological anomalies (17–19%) were disproportionately elevated, consistent with perchlorate-mediated thyroid disruption.[33] The MoH noted that 2025 figures represent only cases reaching functional facilities.[21]

3.5 Preterm Births, Stillbirths, and Perinatal Mortality

Table 3 summarises key indicators. Preterm birth rates rose from 9.7% to 13.6% (↑40.2%).[15] In 2025, 4,100 preterm deliveries occurred (↑52%).[30] Stillbirth rates increased from 6.0 to 10.3/1,000 (↑71.7%).[15] An estimated 6,600 intrauterine deaths occurred in 2025.[30] Post-neonatal mortality increased by >90% within the first week.[30] Approximately 4,900 neonates had abnormal birth weights.[30]

3.6 Spatial Distribution

Table 4 presents governorate-level data. North Gaza and Gaza City exhibited the highest rates: congenital anomalies (7.8 and 6.9/1,000) and miscarriage (520 and 480/1,000). A north-to-south gradient correlated with bombardment intensity. Moran's I = 0.34 ($p = 0.08$), suggesting moderate positive spatial autocorrelation. Getis-Ord Gi identified North Gaza as a significant hotspot for congenital anomalies ($z = 2.31$, $p = 0.021$) and Gaza City for miscarriage ($z = 2.08$, $p = 0.038$). Areas within 3 km of strike clusters exhibited anomaly rates 1.4–1.8 times higher than areas beyond 5 km.

3.7 Sensitivity Analysis

Across underreporting scenarios (10–30%), direction and significance remained consistent (Table 5). Magnitude varied by 8–15%, but conclusions were robust. Alternative baseline periods showed minimal variation.(%7–2±)

4 .DISCUSSION

4.1 Magnitude of Disruption

The documented 67% decline in monthly live births and threefold miscarriage increase represent a demographic shock of extraordinary magnitude. The simultaneous acute elevation across all adverse pregnancy endpoints points to systemic collapse of the gestational environment rather than isolated pathological events. This aligns with local clinical descriptions of "fetal attrition," where cumulative environmental, nutritional, and psychological stressors prevent successful pregnancy continuation.[20]

4.2 Synergistic Mechanisms

The aetiology is multifactorial, driven by three interacting vectors:

Environmental toxicity: Widespread munitions detonation in a confined urban environment generated pervasive contamination. Heavy metals (lead, mercury) and explosive residues (TNT, RDX, perchlorate) are documented teratogens.[6,7] The doubling of congenital anomalies, particularly cardiac and structural defects, correlates with heavy metal-induced embryotoxicity and perchlorate-mediated thyroid disruption.[8,31] The north-to-south spatial gradient and hotspot identification in heavily bombarded areas support this association, though ecological design limits causal inference.

Nutritional deprivation: Catastrophic food insecurity created profound micronutrient deficits. Over 67% of pregnant women suffer severe anaemia,[15] highlighting folic acid and iron deficiency. Folic acid absence in a population exposed to environmental mutagens compounds neural tube defect risk.[32] The disproportionate representation of neural tube defects (12–14% vs. global 5–7%) supports this mechanism.

Healthcare collapse: Destruction of hospitals and ANC disruption eliminated safety nets. Absence of emergency obstetric care, tocolytics, and ultrasound monitoring elevates stillbirth and neonatal mortality.[2,3] The 76.5% reduction in functional hospitals and 88.6% decline in folic acid coverage[15] created conditions where preventable complications became fatal.

4.3 Comparison with Historical Conflict Zones

The Gaza crisis shares epidemiological parallels with other contaminated conflict zones, though speed and density appear uniquely acute.[34] In Fallujah and Basra, elevated congenital anomalies and miscarriages were documented years post-conflict, linked to heavy metals and depleted uranium.[13,14] In Vietnam, Agent Orange's intergenerational teratogenic effects were documented over decades.[35] However, in these settings, effects manifested over 5–10+ years. In Gaza, geographic confinement (365 km²), bombardment intensity (estimated 70,000+ tonnes ordnance), and simultaneous blockade have compressed teratogenic effects into 18–24 months—a phenomenon we term "acute conflict teratogenesis".

4.4 Public Health and Demographic Implications

The "fetal attrition syndrome" documented here constitutes not merely an immediate humanitarian emergency but a long-term demographic catastrophe. The 67% birth decline, if sustained, will result in generational population contraction. The elevated congenital anomaly burden will impose lasting paediatric surgical, developmental, and rehabilitative demands on an already destroyed healthcare system. The epigenetic implications of in-utero exposure to multiple toxicants warrant multi-generational surveillance.[36]

4.5 Limitations

This study is subject to inherent limitations. Underreporting is inevitable given healthcare destruction; sensitivity analyses assuming 10–30% underreporting confirmed trend robustness but reported figures likely represent conservative minimums. Absence of individual-level biomarker data precludes definitive causal attribution. The ecological design describes population-level associations without individual-level inference. Overlapping reporting windows necessitated careful harmonisation. Despite these limitations, consistency across independent sources validates the overarching conclusion.

5 .CONCLUSION AND RECOMMENDATIONS

The Gaza Strip is experiencing a profound reproductive health crisis. Data from 2023–2026 demonstrate catastrophic escalation in miscarriages (↑228%), congenital anomalies (↑94–135%), preterm births (↑52%), stillbirths (↑71.7%), and perinatal mortality, accompanied by 67% birth decline. These outcomes manifest a toxic environment saturated with munitions residue, compounded by malnutrition, anaemia, and healthcare destruction.

Five urgent interventions are recommended: (1) Establish a longitudinal reproductive registry with MoH and UNRWA for congenital anomalies, fetal deaths, and teratogenic exposures; (2) Conduct comprehensive environmental toxicology assessment by UNEP/WHO, including biomonitoring of pregnant women and neonates; (3) Restore maternal supply chains with immediate unrestricted entry of folic acid, iron, oxytocin, and emergency obstetric kits; (4) Implement targeted nutritional interventions addressing anaemia and intrauterine growth restriction; (5) Prepare specialised paediatric and teratological facilities for the anticipated surge in conflict-associated anomalies.

TABLES

Table 1. Impact on Maternal Healthcare Infrastructure (October 2023 – June 2026)

Indicator

Indicator	Pre-Conflict (2022)	Mid-2025	June 2026	% Change
Total hospitals	34	13	8	↓76.5%
Primary healthcare centres	54	12	6	↓88.9%
UNRWA health centres	22	7	4	↓81.8%
ANC coverage (≥4 visits)	95.1%	~40%	~25%	↓73.7%

Table 2. Congenital Anomalies by Organ System (ICD-11)

Organ System	H1 2025	2025	Jan 2026	Spring 2026	Baseline (est.)
110 (34.2%)	Cardiac	20 (29.9%)	105 (33.3%)	130 (33.8%)	~55/yr
45 (14.0%)	Neural tube	8 (11.9%)	40 (12.7%)	55 (14.3%)	~25/yr
60 (18.6%)	Urological	12 (17.9%)	58 (18.4%)	75 (19.5%)	~30/yr
42 (13.0%)	Musculoskeletal	9 (13.4%)	40 (12.7%)	48 (12.5%)	~20/yr
30 (9.3%)	Orofacial	7 (10.4%)	32 (10.2%)	35 (9.1%)	~15/yr
35 (10.9%)	Other	11 (16.4%)	40 (12.7%)	42 (10.9%)	~20/yr
322	TOTAL	67	315	385	~165/yr
6.6	Rate/1,000	3.9	6.5	~8.0	~3.4

Table 3. Preterm Birth, Stillbirth, and Perinatal Mortality

Indicator	Baseline	Conflict	% Change
Preterm birth rate	9.7%	13.6%	↑40.2%
Preterm deliveries (2025)	~2,700/yr	4,100	↑51.9%
Stillbirth rate	6.0/1,000	10.3/1,000	↑71.7%
Intrauterine deaths (2025)	~3,000/yr	~6,600	↑~120%
Abnormal birth weight	~2,500/yr	~4,900	↑~96%
Post-neonatal mortality (wk 1)	Baseline	↑>90%	↑>90%

Table 4. Spatial Distribution by Governorate (2025)

Governorate	Congenital Anomalies	Rate/1,000	Miscarriages	Rate/1,000	Strike Intensity
North Gaza	~85	520	~1,200	Very High	
Gaza City	~110	480	~1,800	Very High	
Deir al-Balah	~45	440	~700	High	
Khan Younis	~50	420	~800	High	
Rafah	~32	390	~500	Moderate	
Total	~322	460	~5,000	—	

Table 5. Sensitivity Analysis: Underreporting Scenarios

Indicator	Observed	+10%	+20%	+30%	Consistent?
Miscarriage rate/1,000	460	506	552	598	☑
Anomaly rate/1,000	6.6	7.3	7.9	8.6	☑
Stillbirth rate/1,000	10.3	11.3	12.4	13.4	☑
Preterm birth %	13.6%	15.0%	16.3%	17.7%	☑

FIGURES

Figure 1. Conceptual Framework: Synergistic Multi-Exposure Model (see Supplementary Material)

Figure 2. Spatial Distribution of Congenital Anomalies by Governorate (GIS Choropleth Map)

Figure 3. Temporal Trends in Reproductive Health Indicators: Gaza, 2019–2026 (Multi-panel Line Graph)

Figure 4. Comparative Bar Chart: Pre-Conflict vs. Conflict Indicators

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SUPPLEMENTARY MATERIAL

Supplementary File S1: Conceptual Framework – Synergistic Multi-Exposure Model (detailed diagram)

Supplementary File S2: Detailed Literature Review (2,800 words)

Supplementary File S3: Extended Methodology (GIS protocols, sensitivity analysis details)

Supplementary File S4: Full Reference List (110 references)

Supplementary File S5: Monthly Data Tables (October 2023 – June 2026)