

Zeina Jamaluddine et al.

## Maternal and neonatal outcomes in the Gaza Strip

This online first version has been peer-reviewed, accepted and edited,  
but not formatted and finalized with corrections from authors and proofreaders

### Maternal and neonatal outcomes in a cohort of pregnant women during conflict, Gaza Strip

Zeina Jamaluddine,<sup>a</sup> Reham Jaffal,<sup>b</sup> Sanaa Al Najjar,<sup>b</sup> Mahmoud Al Kahlout,<sup>b</sup> Tamam Abu Zeid,<sup>b</sup> Hala Mughari,<sup>b</sup> Ghada Al Jadba,<sup>b</sup> Rami Habash,<sup>b</sup> Bassam A Abu Hamad,<sup>c</sup> Akihiro Seita<sup>b</sup> & Oona Maeve Renee Campbell<sup>a</sup>

<sup>a</sup> Faculty of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, Keppel Street, London, WC1E 7HT, England.

<sup>b</sup> United Nations Relief and Works Agency for Palestine Refugees in the Near East, Amman, Jordan.

<sup>c</sup> School of Public Health, Al-Quds University, Gaza City, occupied Palestinian territory, including east Jerusalem.

Correspondence to Zeina Jamaluddine (email: zeina.jamaluddine@lshtm.ac.uk).

(Submitted: 14 April 2025 – Revised version received: 8 October 2025 – Accepted: 5 January 2026 – Published online: 30 March 2026)

#### Abstract

**Objective** To assess the impact of war on maternal and neonatal mortality and health care utilization among pregnant refugee women in the Gaza Strip.

**Methods** The study involved data on pregnancy outcomes for 17 713 refugee women in the Gaza Strip who were pregnant on 8 October 2023 and received antenatal care from the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA). We obtained data from UNRWA's electronic health records, an UNRWA phone survey and the Palestinian Ministry of Health's lists of deaths for October 2023 to June 2024.

**Findings** Overall, 168 maternal deaths were identified, yielding a pregnancy-related mortality ratio of 948 per 100 000 pregnancies compared to a pre-war maternal mortality ratio of 30 per 100 000 live births. The pattern of age-specific, pregnancy-related deaths suggested that most were trauma-related. The stillbirth rate among women with known pregnancy outcomes was 10.3 per 1000 births compared with 6.0 per 1000 pre-war and the neonatal mortality rate was 9.4 per 1000 live births compared with 6.6 per 1000. The preterm birth rate was also higher, at 13.6% versus 9.7% pre-war. Although most deliveries (97.3%) remained facility-based, there was a shift from government to nongovernmental organization facilities. Moreover, post-delivery hospital stays were markedly shorter.

**Conclusion** The conflict in the Gaza Strip was associated with substantial increases in maternal and neonatal mortality and preterm births. Utilization of health services remained high but delivery locations shifted to lower-level facilities and hospital stays shortened, raising concerns about the quality of care.

## Introduction

In the Gaza Strip, the maternal mortality ratio between 2018 and 2022 averaged 30 per 100 000 live births,<sup>1</sup> which was substantially lower than the global average of 223 per 100 000 in 2020.<sup>2</sup> According to the Palestinian Ministry of Health, the neonatal mortality rate was 6.6 per 1000 live births in 2022,<sup>1</sup> which again compared favourably to the 17.3 per 1000 reported globally in 2024;<sup>3</sup> the stillbirth rate was 6.0 per 1000 births,<sup>1</sup> which was also lower than the global rate of 13.9 per 1000.<sup>3</sup> In addition, high proportions of antenatal care (100%), skilled birth attendance (100%) and facility-based delivery (99.4%) confirmed that the health-care system was robust.<sup>4</sup> The total fertility rate was also high, at 3.9 births per woman in 2020.<sup>4</sup>

In 2017, around 48% of women aged 15 to 49 years in the Gaza Strip were original inhabitants (i.e. non-refugees), whereas the remaining 52% were descendants of individuals displaced from their homes in 1948 (i.e. refugees).<sup>5</sup> The United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) provides free primary health-care services to Palestinian refugees through 22 health centres in the Gaza Strip, including antenatal care and partial support for childbirth.<sup>6</sup> In 2010, UNRWA developed an electronic health record (e-health) system that generates comprehensive maternal and neonatal health data. The system includes the registration of pregnancies during antenatal care.<sup>7</sup>

The conflict in the Gaza Strip which started on 7 October 2023 severely disrupted health-care services, including UNRWA's. Health infrastructure was extensively damaged by the Israeli armed forces and many health personnel were killed.<sup>8-11</sup> By January 2025, emergency obstetric and newborn care were available only in seven of 18 partially functioning hospitals, in four of 11 field hospitals and in one community health centre.<sup>12</sup> Access to life-saving emergency obstetric and newborn care was drastically limited and there were reports of caesarean sections being conducted without anaesthesia or electricity.<sup>13</sup> The entire population of the Gaza Strip had an insecure food supply and limited access to water.<sup>14</sup> In 2021, over half of pregnant women in the Gaza Strip were anaemic,<sup>15</sup> which increased the risk of preterm birth and intrauterine fetal growth restriction. Both these conditions had already been made more likely by malnutrition. In addition, infectious disease outbreaks were occurring, which in turn also affected underlying health and nutritional status.<sup>16</sup>

The aims of our study were to derive indicators of maternal and neonatal mortality and of health service use in the Gaza Strip after the outbreak of the conflict and to compare these indicator values to pre-war equivalents. We analysed data from UNRWA's e-health

records, which were supplemented by a phone survey conducted by UNRWA and by data on deaths recorded by the Palestinian Ministry of Health.

## Methods

Our study employed a closed cohort design with a prospective follow-up. All refugee women residing in the Gaza Strip who were recorded as pregnant in UNRWA's e-health records on 8 October 2023 were eligible for inclusion. However, our study cohort comprised only women who had either registered their pregnancy through UNRWA's antenatal care service or notified UNRWA of their pregnancy before 8 October 2023. These women were expected to have given birth by 30 June 2024.

## Data sources

### *UNRWA phone survey*

Some women in the cohort had accessed primary health-care centres with functioning computers and had had their pregnancy outcomes recorded on UNRWA's e-health system. Eligible women without an e-health record of their pregnancy outcome were followed-up by phone to obtain data that supplemented the information extracted from their e-health records (details are available from the online repository).<sup>17</sup> Nurses working with UNRWA in the West Bank volunteered to make the calls. The nurses underwent standardized training, which included protocols for sensitive questioning and data verification procedures, and were debriefed after calling. Up to three attempts were made to contact each woman between May and September 2024. Responses to the phone survey were cross-referenced with the e-health records available for consistency.

### *Palestinian Ministry of Health's lists of deaths*

On 23 October 2023, the Palestinian Ministry of Health began issuing lists of deaths that had occurred since 7 October 2023. List number five, dated 30 June 2024, covered the period during which women in the study cohort would have been expected to give birth and to complete 42 days postpartum. This list reported 28 185 deaths among the entire population of the Gaza Strip, including UNRWA refugees, and recorded each individual's Palestinian registration identification (ID) number, name, sex, age at death and month of death. However, there were indications that deaths may have been underreported.<sup>18</sup>

We used exact (deterministic) matching to link the Palestinian Ministry of Health's lists of deaths with UNRWA records using Palestinian ID numbers. If the death of a woman in the study cohort was recorded in the UNRWA system but there was no record linked to her

ID number in the Palestinian Ministry of Health lists, the lists were searched for her name, allowing for spelling variations in both her first name and surname.

### ***Pre-war maternal and neonatal indicators***

Data on maternal and neonatal health indicators for the Gaza Strip for the period before 7 October 2023 were extracted from UNRWA's e-health records for 2020,<sup>7</sup> from Gaza Health Ministry reports for 2022,<sup>1</sup> and from the 2019 to 2020 Palestine multiple indicator cluster survey,<sup>4</sup> which was part of a household survey programme developed by the United Nations Children's Fund. We re-analysed cluster survey data to generate indicators for the Gaza Strip alone, rather than for all of the occupied Palestinian territory, including east Jerusalem.

### **Data analysis**

We used data on women whose pregnancy outcome was known because they responded to the phone survey or their e-health records were available to produce values for the following indicators: (i) the pregnancy-related mortality ratio; (ii) the stillbirth rate; (iii) the neonatal mortality rate; (iv) the preterm birth rate; (v) the proportion of births in a health facility; (vi) the proportion of births with a skilled birth attendant; (vii) the length of stay in health facilities; and (viii) the caesarean section rate (Box 1). In addition, we derived a pregnancy-related mortality ratio for all women using data from the phone survey, e-health records and the Palestinian Ministry of Health's lists of deaths. A pregnancy-related death was defined as a death that resulted from: (i) a direct maternal cause related to the pregnancy or delivery; (ii) an indirect maternal cause due to the pregnancy exacerbating a pre-existing condition; or (iii) another cause, such as trauma.

As the Palestinian Ministry of Health listed deaths by the month of death rather than the date, for our analysis we assumed that deaths occurred mid-month (i.e. on the 15th). In addition, we conducted a sensitivity analysis in which assumed that all deaths occurred on either the first or last day of the month, respectively. We used UNRWA's expected delivery dates to determine whether a death occurred within 42 days of the expected end of pregnancy (that is, it was pregnancy-related). This approach, used in Reproductive Age Mortality Studies (RAMOS),<sup>19</sup> identifies deceased women of reproductive age and ascertains their pregnancy or postpartum status at the time of death in a variety of ways, such as: (i) through links to pregnancy records (as we did); (ii) through links to birth records; (iii) by interviewing the families of the deceased women; or (iv) by using multiple information sources.

We performed separate analyses of deaths of women: (i) who responded to the phone survey or whose pregnancy outcomes were reported in e-health records; and (ii) women who were unreachable by phone and whose pregnancy outcomes were not reported in e-health records but who were included in the Palestinian Ministry of Health's lists of deaths. First, we calculated mortality indicators for women with known pregnancy outcomes and noted the proportion of their deaths included on the Palestinian Ministry of Health's lists. Second, we added pregnancy-related deaths among women with unknown pregnancy outcomes using the RAMOS linkage approach. Third, we assumed that the degree of underreporting by the Palestinian Ministry of Health was the same for women with unknown pregnancy outcomes as for those with known pregnancy outcomes. We did not perform any poststratification analysis or use weighting to account for differential responses by subregion.

We were able to calculate stillbirth and neonatal mortality rates only for women with known pregnancy outcomes. As stillbirths were not reported on the Palestinian Ministry of Health's lists of deaths, it was not possible to identify stillbirths among women with unknown pregnancy outcomes. Similarly, these lists did not distinguish between neonatal and infant deaths. Instead, deaths were reported for infants younger than 1 year. Moreover, the phone survey did not ask for newborn ID numbers or names, so neonatal deaths could not be linked to Palestinian Ministry of Health lists. Nevertheless, we estimated stillbirth and neonatal mortality rates for the entire study cohort by assuming that the relationship between rates in women with unknown pregnancy outcomes and rates in women with known pregnancy outcomes was the same as the corresponding relationship observed for pregnancy-related deaths. All analyses were performed using Stata v.18 (StataCorp LLC, College Station, United States of America).

Approval to use the data was obtained from the ethics committee of the London School of Hygiene and Tropical Medicine (LSHTM Ethics Ref: 31273) and UNRWA's research review board.

## Results

In total, data for 18 038 women were extracted from UNRWA records. As 325 women were ineligible because they had given birth before 8 October 2023 (and before their expected delivery dates), the study analysis involved the records of a cohort of 17 713 women who were pregnant on 8 October 2023 and who received antenatal care from UNRWA (Fig. 1). The size of the cohort was consistent with the number of women who attended UNRWA

antenatal care services on 7 October 2020, which was 17 351,<sup>17</sup> and was consistent with the expected pattern of age-specific fertility (details are available from the online repository).<sup>17</sup>

For the 17 713 women pregnant on 8 October 2023, information on pregnancy outcomes was obtained from UNRWA's e-health system for 2134 (12.0%) and was sought through the phone survey for 15 579 (88.0%; Fig. 1).<sup>17</sup> However, of the 15 579 followed up by phone, 30 (0.2%) refused to respond and 4621 (29.7%) were unreachable. In addition, 47 women were still pregnant. There was no significant difference in maternal age between women whose pregnancy outcomes were known and those whose outcomes were not known. However, the proportion of women who responded to calls or whose pregnancy outcomes were recorded in the e-health system varied greatly by the registered location of the clinic before the war. Overall, pregnancy outcomes were known for 13 015 women from either phone responses or e-health records: 12 868 had given birth after 28 weeks' gestation; 108 had had miscarriages; 30 had experienced an early fetal death; and nine had died with their pregnancy outcomes not recorded (Fig. 1). The 12 868 pregnancies resulted in a total of 13 044 live births and stillbirths, including 332 twins and 15 triplets. Details of a sensitivity and specificity analysis of linkage to Palestinian Ministry of Health lists of deaths are available from the online repository.<sup>17</sup>

### **Maternal and fetal deaths**

No pregnancy-related deaths were recorded on UNRWA's e-health system. However, the phone survey identified 67 pregnancy-related deaths among the 10 928 successfully contacted women: 35 were also recorded in the Palestinian Ministry of Health lists of deaths and 32 were unique to the phone survey. Among women contacted by phone, there were no deaths on Palestinian Ministry of Health lists that were missed by the phone survey. Nevertheless, 101 deaths on Palestinian Ministry of Health lists were linked to the 4651 women who were either unreachable by phone or refused to respond. Thus, a total of 168 pregnancy-related deaths were identified by combining data from Palestinian Ministry of Health's lists and the phone survey. In the sensitivity analysis, which regarded the day of death in Palestinian Ministry of Health lists as being the first or last day of the month rather than the 15th and which assumed that the end of the puerperium occurred 42 days after the expected delivery date, the estimated number of pregnancy-related deaths in the study cohort was 166 and 171 for these two days, respectively.

Using a denominator of 17 713 pregnancies, the overall pregnancy-related mortality ratio derived from the combined data was 948 per 100 000 pregnancies (Table 1). Table 1 also reports 95% confidence intervals (95% CIs) and the implications of uncertainty in the assumed dates of death in Palestinian Ministry of Health lists. Assuming that Palestinian Ministry of Health data underestimated the number of deaths among women with unknown pregnancy outcomes to the same extent as among women with known pregnancy outcomes, the total number of pregnancy-related deaths was estimated to be 260 (193 among women with unknown pregnancy outcomes and 67 among women with known pregnancy outcomes), which corresponds to a pregnancy-related mortality ratio of 1468 per 100 000 pregnancies (Table 1). We also calculated age-specific, pregnancy-related mortality rates (per 100 000 women) using projected population data from the United Nations Population Fund for May 2023. Age-specific, maternal mortality ratios (i.e. per 100 000 live births) for 2020 were derived using Palestinian Ministry of Health and multiple indicator cluster survey data (Fig. 2).<sup>4</sup> Age-specific, mortality rates for all women in the Gaza Strip between 8 October and 30 June 2024 are also shown in Fig. 2.<sup>20–22</sup>

An UNRWA social autopsy, which was conducted in 2024 separately from our phone study, identified 21 maternal deaths among pregnant refugee women that were not related to trauma: nine from postpartum haemorrhage, three from sepsis, three from other infections, two with unclear causes, and one each of renal failure, Ogilvie syndrome, pulmonary embolism and eclampsia (details are available from the data repository).<sup>17</sup>

Of the 13 044 births for which information was available through the phone survey or the e-health system, 135 were stillbirths, which yielded a stillbirth rate of 10.3 per 1000 births (Table 1). Among the 12 909 live births, there were 121 neonatal deaths, which yielded a neonatal death rate of 9.4 per 1000 live births (Table 1). The ratio of the estimated number of pregnancy-related deaths after correction for Palestinian Ministry of Health underreporting (i.e. 260) to the number of pregnancy-related deaths among women with known pregnancy outcomes (i.e. 67) was 2.88. If we assume the same ratio applies to stillbirths and neonatal deaths, the stillbirth and neonatal mortality rates would be as high as 29.7 per 1000 births and 27.0 per 1000 live births, respectively.

Among the 67 women who were reported to have died on the phone survey, four had an unknown pregnancy outcome, five died with a fetus in utero but with an unknown gestation period, five died before 22 weeks' gestation (i.e. died with a non-viable fetus), five died between 22 and 27 weeks' gestation (i.e. early fetal death), 21 died with a stillbirth (i.e.

at more than 28 weeks' gestation) and 27 had a live birth (12 of these neonates died in the neonatal period). The resulting neonatal mortality rate in the 27 mothers who died but had a live birth was 444 per 1000 live births. Among the 63 women who died and whose pregnancy outcomes were known, only 15 neonates (24%) survived past the first month of life and 48 (76%) did not.

The preterm delivery rate among women with known pregnancy outcomes was 13.6% compared with 9.7% (3704/38 189) in similar women in 2020, a 40% increase.<sup>17</sup>

### **Health service use**

In the 2019 to 2020 multiple indicator cluster survey,<sup>4</sup> 99.4% of deliveries in the Gaza Strip were facility-based, with government hospitals handling 78.3% (Table 2). After the start of the conflict, the proportion of facility-based deliveries remained high among women with known pregnancy outcomes, at 97.4% (12 531/12 868), but the proportion of deliveries in government hospitals was lower, at 60.8% (7828/12 868). For other locations, the proportions were 31.0% (3990/12 868) for nongovernmental organization hospitals, 3.6% (466/12 868) for private sector facilities, 1.9% (247/12 868) and 0.1% (11/12 868) for field hospitals and medical points (which did not exist previously), respectively, and 1.7% (220/12 868) for homes, shelters, tents and ambulances.

Among women with known pregnancy outcomes, the presence of a skilled birth attendant remained high, at 97.4% (12 534/12 868) compared with 100% in 2019 to 2020 (Table 2),<sup>4</sup> but the composition of the providers changed. The proportion of births attended by a medical doctor decreased from 87.5% to 76.3% (9818/12 868), whereas the proportion attended by a nurse or midwife increased from 12.5% to 21.1% (2716/12 868). After the start of the war, the proportion attended by a relative or friend was 1.0% (125/12 868) and the proportion of unattended births was 0.3% (39/12 868). The caesarean section rate decreased somewhat from 25.6% among UNRWA refugees in 2020 to 19.5% (2512/12 868) among women with known pregnancy outcomes in our study.

The median length of stay in a facility after delivery was shorter among women with known pregnancy outcomes than among the Gazan population pre-conflict. For vaginal deliveries, the median stay was 20 h (inter-quartile range, IQR: 6–36) in 2019 to 2020 and 6 h (IQR 3–10) in our study (Table 2).<sup>4</sup> For caesarean section births, the median stay was 60 h (IQR: 36–84) in 2019 to 2020 and 24 h (IQR 12–24) in our study. Correspondingly, the proportion of women discharged within 24 h of vaginal delivery increased from 58.6% in

2019 to 2020 to 88.9% (5221/5874) and the proportion discharged within 72 h of caesarean section increased from 72.8% in 2019 to 2020 to 93.9% (1427/1520).

## Discussion

This study, which collected data from Palestinian Ministry of Health lists of deaths, UNRWA e-health records and an UNRWA phone survey, documents the serious deterioration in maternal and neonatal health among refugees in the Gaza Strip following the onset of the conflict on 7 October 2023. Moreover, roughly a quarter of women in our study cohort were unreachable by phone. As these women and their babies probably had the worst outcomes and the worst experiences of using health care, our findings are likely to represent a best-case scenario and to have underestimated adverse events.

Our analysis revealed that pregnancy-related, stillbirth and neonatal mortality in the Gaza Strip in late 2023 and 2024 were higher than in previous years. In 2022, 13 (non-trauma related) maternal deaths were reported in the Gaza Strip among refugee and non-refugee populations combined, corresponding to a maternal mortality ratio of 17 per 100 000 live births.<sup>1,20</sup> In our study cohort, the pregnancy-related mortality ratio was 948 per 100 000 pregnancies after the start of the war. Once the underreporting of deaths by the Palestinian Ministry of Health is considered, the pregnancy-related mortality ratio may have been 1468 per 100 000 pregnancies. Overall, almost half of deaths identified through our phone survey were not on health ministry lists and a previous study indicated that these lists underreported all deaths by 41% (95% CI: 32–52).<sup>18</sup> In our results, we present a wide range for the pregnancy-related mortality ratio, from a lower bound based on observed deaths among women with known pregnancy outcomes to an upper bound derived by incorporating the underreporting of deaths among women with unknown pregnancy outcomes, which gave a plausible uncertainty range between 390 and 4723 deaths per 100 000 pregnancies. Nevertheless, the uncorrected pregnancy-related mortality ratio of 948 per 100 000 deaths among all pregnant women represents a more than 30-fold increase over the average maternal or pregnancy-related mortality ratio in the Gaza Strip for 2018 to 2022 (i.e. 30 per 100 000 live births) and exceeds the increases documented in other conflicts.<sup>1,23</sup>

We recorded pregnancy-related mortality rather than maternal mortality because it was not feasible to conduct verbal autopsies by phone under war conditions. In fact, the UNRWA social autopsy investigation also faced substantial challenges, including difficulty contacting women due to phone or network problems, siege conditions and attacks on

hospitals and missing data (such as dates of death), which made it hard to establish an accurate denominator for the total number of women giving birth.<sup>22</sup> The widely used time-of-death definition does not require a cause of death to be established. In hindsight, it would have been useful to ascertain, via a single question, if a death was traumatic. Nevertheless, the relatively small number of maternal deaths recorded in the social autopsy compared to the number of pregnancy-related deaths we identified suggests that the main cause of death among pregnant women and women who had recently given birth in the Gaza Strip was probably trauma. This interpretation is reinforced by the absence of a J-shaped pattern for age-specific mortality ratios.<sup>24</sup>

When mothers died, their babies' outcomes were dire. Among live births to mothers who died, the neonatal mortality rate was astronomical, at 444 per 1000 live births, which was 47 times higher than among live births to mothers who survived. This excess was higher than that estimated in a systematic review of low- and middle-income countries, which found that the risk of death among neonates whose mothers died was 11.3 times that among neonates whose mother survived.<sup>25</sup> We also observed elevated stillbirth and neonatal mortality rates, which aligns with existing research on conflicts.<sup>23</sup>

The conflict also precipitated a shift in delivery location, probably due to extensive damage to the health infrastructure by the Israeli armed forces.<sup>9-11</sup> Deliveries in government hospitals decreased, whereas those in nongovernmental organization hospitals and field hospitals increased. Concurrently, the median length of post-delivery stay in health facilities decreased sharply, possibly because of shortages in nursing staff and the precarious situation in health facilities.<sup>12</sup> This reduction, combined with more deliveries in field hospitals and at home, may have influenced the quality of care and increased the risk of maternal and neonatal complications. These concerns are further compounded by the increase in the preterm birth rate we observed, which may have been linked to conflict-induced stress, widespread malnutrition and absent or inadequate antenatal care services.<sup>26</sup> Our findings reflect service use among women with known pregnancy outcomes; service use may have been less and the preterm birth rate may have been higher among women with unknown pregnancy outcomes.

Our study's strengths are the quantity of information available on women who were pregnant on 8 October 2023 and our use of multiple, linked data sources, which provided a comprehensive and nuanced view of the situation in the Gaza Strip. This triangulation approach was critical because the phone survey identified only 67 pregnancy-related deaths,

whereas combining data from the phone survey and Palestinian Ministry of Health lists revealed between 166 and 171 deaths, depending on when the deaths were assumed to have occurred in each month. Our approach underscores the importance of using multiple data sources to accurately assess outcomes in complex emergencies.

Implementing effective maternal and perinatal death surveillance and response systems during humanitarian crises or conflicts is challenging. The identification, reporting and review processes around deaths can be severely compromised.<sup>27</sup> The underreporting of deaths we observed aligns with experiences in other conflict zones where mortality surveillance is hindered by security concerns, damaged infrastructure and overwhelmed health systems. Nevertheless, the multisource approach to data collection we employed is a pragmatic way of meeting these challenges. Our study was greatly aided by UNRWA's antenatal care records of pregnancies which could be followed up to ascertain outcomes. However, our reliance on UNRWA records also meant that our findings primarily reflected the experience of the refugee population in the Gaza Strip and their generalizability to the entire population may be limited. We recognize that the risk of death and access to health care may have been different for unregistered refugees and non-refugee Palestinians.

Our study had some limitations. First, we used Palestinian ID numbers as unique identifiers to link UNRWA data and Palestinian Ministry of Health lists of deaths. However, mismatches could have occurred because of data entry errors in either system, as well as because of underreporting of deaths by the Palestinian Ministry of Health. Consequently, we may have underestimated mortality rates if deaths were missed or, more improbably, overestimated rates if there were false-positive links. Not all women in the study cohort had completed the 42-day period after their expected delivery dates or had given birth, which could also have led to an underestimate of the risk of death. Second, recall bias may have affected phone survey responses, particularly regarding the exact timing of events. Although our use of pregnancy-related mortality rather than maternal mortality affected comparability with pre-war estimates, it was necessary given data collection constraints during active conflict. Third, stillbirth and neonatal mortality rates among women with unknown pregnancy outcomes were estimated from rates among women with known pregnancy outcomes by assuming a ratio derived from the Palestinian Ministry of Health underreporting of pregnancy-related deaths among women with known pregnancy outcomes.

Our study is an attempt to systematically document maternal and perinatal mortality during an active war. The study provides evidence that the conflict in the Gaza Strip severely

affected maternal health outcomes and patterns of access to health care. These findings demand an immediate and sustained international response focused on: (i) supporting a ceasefire to end traumatic deaths due to bombing; (ii) protecting health-care facilities and personnel; (iii) ensuring unimpeded access to emergency obstetric and newborn care; (iv) addressing the underlying determinants of maternal and neonatal ill-health, including problems with food security, water and sanitation; and (v) supporting families in which a mother who died had given birth to a live infant. In the longer term, we would also argue for: investing in rebuilding an equitable health system for the Gaza Strip and conducting a comprehensive needs assessment.

### **Acknowledgements**

We thank UNRWA staff in the West Bank, physicians, nurses, midwives and allied health workers in the Gaza Strip, and Palestinian women involved in the study. We dedicate the study to the memory of the UNRWA gynaecologist Sirin Mohammed Al Attar.

### **Funding:**

The analysis was supported by the United Kingdom Economic and Social Research Council (grant number ES/Z503265/1).

### **Competing interests:**

None declared.

### **References**

1. Annual report 2022. Ministry of Health, Southern Governates, Gaza Strip. Gaza City: Ministry of Health Gaza; 2023. Available from: <https://www.moh.gov.ps/portal/annual-report-moh-gaza-2023/> [cited 2025 Jun 18].
2. Trends in maternal mortality 2000 to 2020: estimates by WHO, UNICEF, UNFPA, World Bank Group and UNDESA/Population Division. Geneva: World Health Organization; 2023. Available from: <https://www.who.int/publications/i/item/9789240068759> [cited 2025 Jun 18].
3. World health statistics 2024: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization; 2024. Available from: <https://www.who.int/publications/i/item/9789240094703> [cited 2025 Jun 18].
4. Palestinian Multiple Indicator Cluster Survey 2019–2020. Survey findings report. Ramallah: Palestinian Central Bureau of Statistics; 2021. Available from: <https://www.unicef.org/sop/reports/palestinian-multiple-indicator-cluster-survey> [cited 2025 Jun 18].
5. Population and housing census 2017, third round. West Bank and Gaza, 2017. Ramallah: Palestinian Central Bureau of Statistics; 2021. Available from: <https://www.pcbs.gov.ps/PCBS-Metadatas-en-v5.2/index.php/catalog/663> [cited 2025 Jun 18].

6. Department of Health Annual Report. 2023. Amman: United Nations Relief and Works Agency for Palestine Refugees in the Near East; 2023. Available from: <https://reliefweb.int/report/occupied-palestinian-territory/unrwa-department-health-annual-report-2023-enar> [cited 2025 Jun 18].
7. Jamaluddine Z, Seita A, Ballout G, Al-Fudoli H, Paolucci G, Albaik S, et al. Establishment of a birth-to-education cohort of 1 million Palestinian refugees using electronic medical records and electronic education records. *Int J Popul Data Sci.* 2023 Oct 23;8(1):2156. <https://doi.org/10.23889/ijpds.v8i1.2156> PMID:38414543
8. Wispelwey B, Mills D, Asi YM, Hammoudeh W, Kunichoff D, Ahmed AK. Civilian mortality and damage to medical facilities in Gaza. *BMJ Glob Health.* 2024 May 16;9(5):e014756. <https://doi.org/10.1136/bmjgh-2023-014756> PMID:38760024
9. Kunichoff D, Mills D, Asi Y, Abdulrahim S, Wispelwey B, Tanous O, et al. Are hospitals collateral damage? Assessing geospatial proximity of 2000 lb bomb detonations to hospital facilities in the Gaza Strip from October 7 to November 17, 2023. *PLOS Glob Public Health.* 2024 Oct 10;4(10):e0003178. <https://doi.org/10.1371/journal.pgph.0003178> PMID:39387878
10. Mahase E. Gaza: Israeli airstrikes kill doctors and damage healthcare facilities. *BMJ.* 2021 May 20;373(1300):n1300. <https://doi.org/10.1136/bmj.n1300> PMID:34016591
11. Hamamra B, Abuzant M, Mahamid F. The decimation of Gaza's health care system – hospitals destroyed and lives endangered. *Int J Soc Determinants Health Health Serv.* 2026 Jan;56(1):30–40. <https://doi.org/10.1177/27551938251378096> PMID:40956650
12. “Five babies in one incubator.” Violations of pregnant women's rights amid Israel's assault on Gaza. New York: Human Rights Watch; 2025. Available from: <https://www.hrw.org/report/2025/01/28/five-babies-one-incubator/violations-pregnant-womens-rights-amid-israels-assault> [cited 2025 Jun 18].
13. Elnakib S, Fair M, Mayrhofer E, Afifi M, Jamaluddine Z. Pregnant women in Gaza require urgent protection. *Lancet.* 2024 Jan 20;403(10423):244. [https://doi.org/10.1016/S0140-6736\(23\)02835-0](https://doi.org/10.1016/S0140-6736(23)02835-0) PMID:38219768
14. Haan N, Hailey P, Maxwell D, Seal A, Lopez J Famine Review Committee. Gaza Strip, March 2024. Conclusions and recommendations. Rome: Food and Agriculture Organization; 2024. Available from: [https://www.un.org/unispal/wp-content/uploads/2024/03/IPC\\_Famine\\_Committee\\_Review\\_Report\\_Gaza\\_Strip\\_Acute\\_Food\\_Insecurity\\_Feb\\_July2024\\_Special\\_Brief.pdf](https://www.un.org/unispal/wp-content/uploads/2024/03/IPC_Famine_Committee_Review_Report_Gaza_Strip_Acute_Food_Insecurity_Feb_July2024_Special_Brief.pdf) [cited 2025 Jun 18].
15. Hasumi T, Mahmassani H. Micronutrient deficiencies in the Palestinian territories: identifying the bottlenecks of anemia prevention and control and assessing the feasibility of an oil fortification program. Washington, DC: World Bank; 2021. <https://doi.org/10.1596/37078>
16. Hussein S, Ahmed SK, Qurbani K, Fareeq A, Essa RA. Infectious diseases threat amidst the war in Gaza. *J Med Surg Public Health.* 2024;2:100067. <https://doi.org/10.1016/j.glmedi.2024.100067>

17. Jamaluddine Z. Supplementary material – maternal and neonatal outcomes Gaza [online repository]. London: Figshare; 2026. <https://doi.org/10.6084/m9.figshare.31410513>
18. Jamaluddine Z, Abukmail H, Aly S, Campbell OMR, Checchi F. Traumatic injury mortality in the Gaza Strip from Oct 7, 2023, to June 30, 2024: a capture-recapture analysis. *Lancet*. 2025 Feb 8;405(10477):469–77. [https://doi.org/10.1016/S0140-6736\(24\)02678-3](https://doi.org/10.1016/S0140-6736(24)02678-3) PMID:39799952
19. Graham WJ, Ahmed S, Stanton C, Abou-Zahr C, Campbell OM. Measuring maternal mortality: an overview of opportunities and options for developing countries. *BMC Med*. 2008 May 26;6(1):12. <https://doi.org/10.1186/1741-7015-6-12> PMID:18503716
20. National maternal mortality report 2020. Jerusalem: United Nations Population Fund in Palestine; 2022. Available from: <https://palestine.unfpa.org/en/publications/national-maternal-mortality-report-2020-1> [cited 2025 Jun 18].
21. State of Palestine – subnational population statistics [internet]. New York: United Nations Office for the Coordination of Humanitarian Affairs (OCHA); 2023. Available from: <https://data.humdata.org/dataset/cod-ps-pse> [cited 2025 Jun 18].
22. Mary M, Murhimalika CH. Improving maternal and newborn health in the DRC: the importance of MPDSR in crises. Baltimore: AlignMNH; 2025. Available from: <https://www.alignmnh.org/2025/03/31/improving-maternal-and-newborn-health-in-the-drc-the-importance-of-mpdsr-in-crises/> [cited 2025 Jun 18].
23. Jawad M, Hone T, Vamos EP, Cetorelli V, Millett C. Implications of armed conflict for maternal and child health: A regression analysis of data from 181 countries for 2000-2019. *PLoS Med*. 2021 Sep 28;18(9):e1003810. <https://doi.org/10.1371/journal.pmed.1003810> PMID:34582455
24. Blanc AK, Winfrey W, Ross J. New findings for maternal mortality age patterns: aggregated results for 38 countries. *PLoS One*. 2013 Apr 16;8(4):e59864. <https://doi.org/10.1371/journal.pone.0059864> PMID:23613716
25. Nguyen DTN, Hughes S, Egger S, LaMontagne DS, Simms K, Castle PE, et al. Risk of childhood mortality associated with death of a mother in low-and-middle-income countries: a systematic review and meta-analysis. *BMC Public Health*. 2019 Oct 11;19(1):1281. <https://doi.org/10.1186/s12889-019-7316-x> PMID:31601205
26. Keasley J, Blickwedel J, Quenby S. Adverse effects of exposure to armed conflict on pregnancy: a systematic review. *BMJ Glob Health*. 2017 Nov 28;2(4):e000377. <https://doi.org/10.1136/bmjgh-2017-000377> PMID:29333283
27. Russell N, Tappis H, Mwanga JP, Black B, Thapa K, Handzel E, et al. Implementation of maternal and perinatal death surveillance and response (MPDSR) in humanitarian settings: insights and experiences of humanitarian health practitioners and global technical expert meeting attendees. *Conf Health*. 2022 May 7;16(1):23. <https://doi.org/10.1186/s13031-022-00440-6> PMID:35526012

**Box 1. Indicator definitions, study of maternal and neonatal outcomes in pregnant women, Gaza Strip, 2023–2024**

*Pregnancy-related mortality ratio*

The number of all deaths of women during pregnancy and childbirth and within 42 days of termination of the pregnancy, regardless of cause, per 100 000 pregnancies

*Stillbirth rate*

The number of fetal deaths at 28 weeks' gestation or later (i.e. stillbirths) per 1000 births

*Neonatal mortality rate*

The number of neonates who died within the first 28 days of life per 1000 live births

*Preterm birth rate*

The percentage of live births that occurred before 37 weeks' gestation

*Location of delivery distribution*

The percentage of stillbirths and live births delivered in a specific location (e.g. a hospital or home)

*Skilled birth attendance prevalence*

Percentage of stillbirths and live births attended by a skilled birth attendant (e.g. a midwife or doctor)

*Length of stay in a health facility*

Average duration (in hours) of mothers' stays in a facility after delivery, by mode of delivery (i.e. caesarean section or vaginally)

*Caesarean section rate*

Percentage of stillbirths and live births delivered by caesarean section

**Table 1. Maternal and fetal deaths, study of maternal and neonatal outcomes in pregnant women, Gaza Strip, 2023–2024**

| Indicator and study population                                                                                                                                                                                            | No. women in study population <sup>a</sup> | Indicator value                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|--------------------------------------------------|
| <b>Pregnancy-related mortality ratio</b>                                                                                                                                                                                  |                                            |                                                  |
| All pregnant women, <sup>b</sup> assuming deaths occurred on the 15 <sup>th</sup> of each month (no correction for Palestinian Ministry of Health underreporting of deaths) <sup>c</sup>                                  | 17 713                                     | 948 (95% CI: 805–1092) per 100 000 pregnancies   |
| All pregnant women, <sup>b</sup> assuming deaths occurred at the start or end of each month, respectively, rather than mid-month (no correction for Palestinian Ministry of Health underreporting of deaths) <sup>d</sup> | 17 713                                     | 937–965 per 100 000 pregnancies                  |
| All pregnant women, <sup>b</sup> with a correction for Palestinian Ministry of Health underreporting of deaths for women who refused to respond to, or were unreachable by, the phone survey                              | 17 713                                     | 1468 (95% CI: 1291–1645) per 100 000 pregnancies |
| Women whose pregnancy outcome was known <sup>e</sup>                                                                                                                                                                      | 13 062                                     | 513 (95% CI: 390–635) per 100 000 pregnancies    |
| Women who refused to respond to, or were unreachable by, the phone survey (no correction for Palestinian Ministry of Health underreporting of deaths)                                                                     | 4 651                                      | 2172 (95% CI: 1753–2591) per 100 000 pregnancies |
| Women who refused to respond to, or were unreachable by, the phone survey, with a correction for Palestinian Ministry of Health underreporting of deaths                                                                  | 4 651                                      | 4150 (95% CI: 3577–4723) per 100 000 pregnancies |
| <b>Stillbirth rate</b>                                                                                                                                                                                                    |                                            |                                                  |
| Women whose pregnancy outcome was known and who had a livebirth or stillbirth                                                                                                                                             | 13 044 <sup>f</sup>                        | 10.3 (95% CI: 8.6–12.1) per 1000 births          |
| <b>Neonatal mortality rate</b>                                                                                                                                                                                            |                                            |                                                  |
| Women whose pregnancy outcome was known and who had a live birth                                                                                                                                                          | 12 909 <sup>g</sup>                        | 9.4 (95% CI: 7.7–11.0) per 1000 live births      |
| <b>Preterm delivery rate</b>                                                                                                                                                                                              |                                            |                                                  |
| Women whose pregnancy outcome was known and who had a livebirth with a known gestational age <sup>e</sup>                                                                                                                 | 12 127 <sup>h</sup>                        | 13.6% (95% CI: 13.0–14.2) of live births         |

CI: confidence interval; UNRWA: United Nations Relief and Works Agency for Palestine Refugees in the Near East.

<sup>a</sup> The numbers listed are for women who were pregnant on 8 October 2023, unless otherwise indicated.

<sup>b</sup> All refugee women residing in the Gaza Strip who were recorded as pregnant on 8 October 2023 in e-health records established by the UNRWA.

<sup>c</sup> The Health Ministry listed deaths by month. For the main analysis, we assumed all deaths occurred on 15th of each month.

<sup>d</sup> The health ministry listed deaths by month. In a sensitivity analysis, we assumed that all deaths occurred on the first or last day of the month, respectively, rather than on the 15th, as assumed in the main analysis.

<sup>e</sup> Information about pregnancy outcomes was obtained through an UNRWA phone survey or from UNRWA e-health records.

<sup>f</sup> The number shown is for all births.

<sup>g</sup> The number shown is for live births.

<sup>h</sup> The number shown is for live births to women whose gestational age was known. Data on gestational age were missing for 782 live births.

**Table 2. Health service use, study of maternal and neonatal outcomes in pregnant women, Gaza Strip, 2023–2024**

| Health service use indicator                                                | Indicator value                                                                     |                                                                                        |                                                                                                                   |
|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
|                                                                             | Weighted % <sup>a</sup>                                                             | No. of women (%; 95% CI) <sup>b</sup>                                                  |                                                                                                                   |
|                                                                             | 2019–2020 live births among non-refugees and UNRWA refugees <sup>c</sup> (n = 1009) | UNRWA 2020 e-health records of live births and stillbirths among refugees (n = 38 189) | Live births and stillbirths to refugee women recorded by UNRWA as pregnant on 8 October <sup>d</sup> (n = 12 868) |
| <b>Location of delivery</b>                                                 |                                                                                     |                                                                                        |                                                                                                                   |
| All health-care facilities                                                  | 99.4                                                                                | 38 172 (99.9; 99.9–100)                                                                | 12 531 (97.4; 97.1–97.7)                                                                                          |
| Government hospital                                                         | 78.3                                                                                | 38 014 (99.5; 99.5–99.6)                                                               | 7 828 (60.8; 60.0–61.7)                                                                                           |
| NGO hospital                                                                | 5.1                                                                                 | 0 (0; NA)                                                                              | 3 990 (31.0; 30.2–31.8)                                                                                           |
| Private hospital                                                            | 15.7                                                                                | 158 (0.4; 0.3–0.5)                                                                     | 466 (3.6; 3.3–3.9)                                                                                                |
| Field hospital                                                              | 0.0                                                                                 | 0 (0; NA)                                                                              | 247 (1.9; 1.7–2.2)                                                                                                |
| Medical point                                                               | 0.0                                                                                 | 0 (0; NA)                                                                              | 11 (0.1; 0.0–0.1)                                                                                                 |
| Home, shelter, tent or ambulance                                            | 0.4                                                                                 | 17 (0.04; 0.0–0.1)                                                                     | 220 (1.7; 1.5–1.9)                                                                                                |
| Missing data                                                                | NA                                                                                  | 0.0 (0; NA)                                                                            | 106 (0.8; 0.7–1.0)                                                                                                |
| <b>Birth attendant</b>                                                      |                                                                                     |                                                                                        |                                                                                                                   |
| All skilled birth attendants                                                | 100                                                                                 | ND                                                                                     | 12 534 (97.4; 97.1–97.7)                                                                                          |
| Medical doctor                                                              | 87.5                                                                                | ND                                                                                     | 9 818 (76.3; 75.6–77.0)                                                                                           |
| Nurse or midwife                                                            | 12.5                                                                                | ND                                                                                     | 2 716 (21.1; 20.4–21.8)                                                                                           |
| Relative, friend, family member or dayae                                    | 0.0                                                                                 | ND                                                                                     | 125 (1.0; 0.8–1.1)                                                                                                |
| No attendant                                                                | 0.0                                                                                 | ND                                                                                     | 39 (0.3; 0.2–0.4)                                                                                                 |
| Missing data                                                                | NA                                                                                  | ND                                                                                     | 170 (1.3; 1.1–1.5)                                                                                                |
| <b>Caesarean section rate</b>                                               |                                                                                     |                                                                                        |                                                                                                                   |
| All health-care facilities                                                  | 22.5                                                                                | 9 770 (25.6; 25.1–26.0)                                                                | 2 512 (19.5; 18.8–20.2)                                                                                           |
| Government hospitals                                                        | 22.5                                                                                | 1 366 (17.5; 16.6–18.3) <sup>f</sup>                                                   | 1 366 (17.5; 16.6–18.3) <sup>f</sup>                                                                              |
| NGO hospitals                                                               | 16.0                                                                                | 990 (24.8; 23.5–26.2) <sup>f</sup>                                                     | 990 (24.8; 23.5–26.2) <sup>f</sup>                                                                                |
| Private hospitals                                                           | 34.5                                                                                | 97 (20.8; 17.1–24.5) <sup>f</sup>                                                      | 97 (20.8; 17.1–24.5) <sup>f</sup>                                                                                 |
| Field hospitals                                                             | NA                                                                                  | 53 (21.5; 16.3–26.6) <sup>f</sup>                                                      | 53 (21.5; 16.3–26.6) <sup>f</sup>                                                                                 |
| <b>Length of facility stay in hours, median (IQR)</b>                       |                                                                                     |                                                                                        |                                                                                                                   |
| All births                                                                  | 36 (6–60)                                                                           | ND                                                                                     | 6 (3–14) <sup>g</sup>                                                                                             |
| Vaginal deliveries                                                          | 20 (6–36)                                                                           | ND                                                                                     | 6 (3–10) <sup>g</sup>                                                                                             |
| Caesarean section deliveries                                                | 60 (36–84)                                                                          | ND                                                                                     | 24 (12–24) <sup>g</sup>                                                                                           |
| <b>Women staying in facility &lt; 24 h after vaginal delivery</b>           | 58.6                                                                                | ND                                                                                     | 5 221 (88.9; 88.1–89.7) <sup>h</sup>                                                                              |
| <b>Women staying in facility &lt; 72 h after caesarean section delivery</b> | 72.8                                                                                | ND                                                                                     | 1 427 (93.9; 92.7–95.1) <sup>h</sup>                                                                              |

CI: confidence interval; IQR: interquartile range; NA: not applicable; ND: not determined; NGO: nongovernmental organization; UNRWA: United Nations Relief and Works Agency for Palestine Refugees in the Near East.

<sup>a</sup> The numbers listed are percentages, unless otherwise indicated.

<sup>b</sup> The figures listed are the number of women, percentages and 95% confidence intervals, unless otherwise indicated.

<sup>c</sup> Numbers for individual indicators were not available from the multiple indicator cluster survey as sampling weighting had been applied.<sup>4</sup>

<sup>d</sup> Data on pregnancy outcome were obtained by phone survey and from e-health records established by UNRWA.

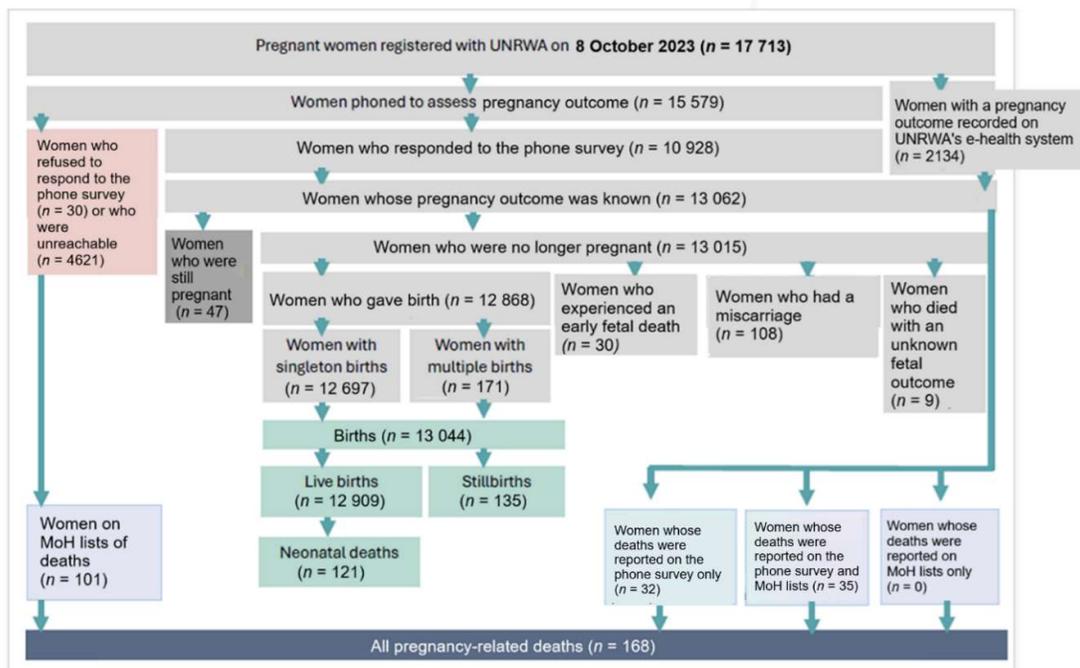
<sup>e</sup> A *daya* is a traditional birth attendant.

<sup>f</sup> The denominator was the number of births that took place in the specific location.

<sup>g</sup> This information was available for only 57.4% of the sample (i.e. for 7394 women who gave birth).

<sup>h</sup> The denominator was the number of women who gave birth by that specific mode of delivery (i.e. vaginal or caesarean-section).

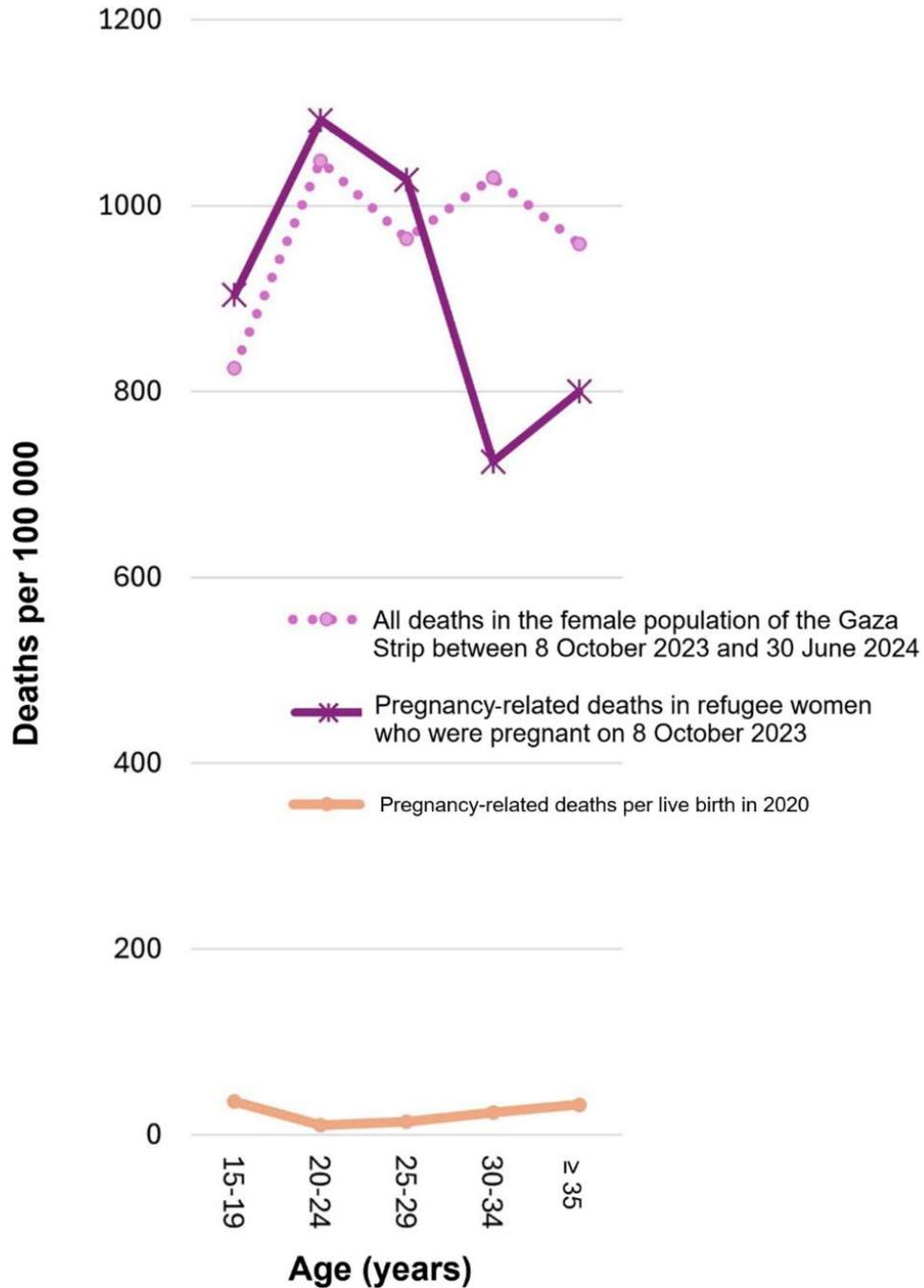
Fig. 1. Flowchart, study of maternal and neonatal outcomes in pregnant women, Gaza Strip, 2023–2024



UNRWA: United Nations Relief and Works Agency for Palestine Refugees in the Near East.

Notes. Information on pregnancy outcomes was obtained by phone survey and from e-health records established by UNRWA. Among women who died with an unknown fetal outcome, five had a fetus in utero and four had an unknown fetal status. Multiple births included 332 twins and 15 triplets.

Fig. 2. Deaths of women in the Gaza Strip before and after the start of the war, study of maternal and neonatal outcomes in pregnant women, Gaza Strip, 2023–2024



Notes. Female death rates between 8 October 2023 and 30 June 2024 were derived from lists of deaths issued by the Palestinian Ministry of Health.<sup>18</sup> Data on pregnancy-related deaths in women registered as pregnant on 8 October 2023 were derived in the current study. We derived data on maternal mortality ratios for 2020 from United Nations Population Fund data for that year.<sup>20</sup>