

# Violent and non-violent death tolls for the Gaza conflict: new primary evidence from a population-representative field survey



Michael Spagat, Jon Pedersen, Khalil Shikaki, Michael Robbins, Eran Bendavid, Håvard Hegre, Debarati Guha-Sapir



## Summary

**Background** High-quality mortality estimates are crucial for understanding the human cost of conflict. The Gaza Ministry of Health (MoH) has provided regular updates to their violent death toll for the Gaza Strip following Oct 7, 2023, but these reports have attracted both criticism and support. Independent estimates of both violent and non-violent deaths were needed.

**Methods** We conducted a population-representative household survey, the Gaza Mortality Survey, between Dec 30, 2024, and Jan 5, 2025. We surveyed 2000 households across 200 primary sampling units, documenting the vital status of 9729 household members as of Oct 6, 2023, plus newborns. The sample was stratified by dwelling type and Governorate of origin. We used raking procedures to adjust for demographic characteristics and calculated confidence intervals using Taylor series linearisation. Sampling occurred in accessible areas, with displaced populations representing inaccessible Governorates.

**Findings** We estimated 75 200 violent deaths (95% CI 63 600–86 800) between Oct 7, 2023, and Jan 5, 2025, representing approximately 3·4% of the Gaza Strip's pre-conflict population. Women, children (ie, younger than 18 years), and older people (ie, older than 64 years) comprised 56·2% (95% CI 50·4–61·9) of violent deaths, totalling 42 200 deaths (95% CI 33 100–51 300). We also estimated 16 300 non-violent deaths (12 300–20 200), of which 8540 (4540–12 500) represent excess deaths above pre-conflict projections. The MoH figure for this period (49 090 violent deaths) was 34·7% below our central estimate.

**Interpretation** This first independent population survey of mortality in the Gaza Strip shows that violent deaths have substantially exceeded official figures whereas the demographic composition of casualties aligns with MoH reporting. Non-violent excess deaths, although substantial, are lower than some projections have suggested. These findings show the feasibility of mortality surveillance in active conflict zones and provide crucial empirical foundations for assessing the true human cost of the conflict.

**Funding** European Research Council Grant 101055176, ANTICIPATE, and the Center for Research on the Epidemiology of Disaster at Université Catholique de Louvain.

**Copyright** © 2026 The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY 4.0 license.

## Introduction

High-quality war mortality estimates play a crucial role in illuminating the human cost of conflict, as shown by studies in Kosovo, Iraq, and Darfur.<sup>1–3</sup> During active conflict, however, such estimates are challenging to obtain due to security constraints and population displacement. The Gaza Ministry of Health (MoH) has provided regular updates to the violent death toll in the Gaza Strip since Oct 7, 2023. However, MoH reports have attracted both criticism<sup>4</sup> and support.<sup>5,6</sup>

A capture–recapture analysis published in 2025 by Jamaluddine and colleagues<sup>5</sup> estimated 64 260 deaths (95% CI 55 298–78 525) due to traumatic injury to June 30, 2024. However, two of three data sources were MoH-generated, limiting the study's independence from official figures. Multiple plausible models using the three data sources estimated wide-ranging confidence

intervals (47 457 to 88 332 deaths). Moreover, MoH-based studies<sup>5,6</sup> do not address non-violent excess deaths.

Information on non-violent excess deaths in the Gaza Strip remains scant. One analysis<sup>7</sup> projected that non-violent deaths could be four times as high as violent deaths, whereas physicians working in the Gaza Strip<sup>8</sup> claimed tens of thousands of deaths due to starvation and its complications. However, these estimates do not have empirical foundation. Médecins Sans Frontières surveyed 2523 staff and family members, finding a death rate of just over 2% with 48% of blast-related deaths occurring in children.<sup>9</sup> However, this staff census was not population-representative. To date, no population-representative survey has provided independent estimates of either violent or non-violent deaths for the Gaza conflict.

We present results from the Gaza Mortality Survey (GMS), which is, to our knowledge, the first

*Lancet Glob Health* 2026

Published Online  
February 18, 2026  
[https://doi.org/10.1016/S2214-109X\(25\)00522-4](https://doi.org/10.1016/S2214-109X(25)00522-4)

See Online/Comment  
[https://doi.org/10.1016/S2214-109X\(26\)00015-X](https://doi.org/10.1016/S2214-109X(26)00015-X)

For the Arabic translation of the abstract see Online for appendix 1

Department of Economics, Royal Holloway University of London, Egham, UK (Prof M Spagat PhD); Oslo, Norway (J Pedersen MA); Palestinian Center for Policy and Survey Research, Ramallah, occupied Palestinian territory (K Shikaki PhD); Department of Politics, Princeton University, Princeton, NJ, USA (M Robbins PhD); Primary Care and Population Health, Department of Medicine, Stanford University, Stanford, CA, USA (Prof E Bendavid MD MS); Peace Research Institute, Oslo, Norway (Prof H Hegre PhD); Centre for Research on Epidemiology of Disasters, Université Catholique de Louvain, Ottignies, Louvain-la-Neuve, Belgium (Prof D Guha-Sapir PhD)

Correspondence to: Prof Michael Spagat, Department of Economics, Royal Holloway University of London, Egham TW20 0EX, UK  
[m.spagat@rhul.ac.uk](mailto:m.spagat@rhul.ac.uk)

### Research in context

#### Evidence before this study

We searched PubMed, Google Scholar, and grey literature from Oct 7, 2023, to Dec 30, 2024, using terms including “Gaza mortality”, “Gaza death toll”, “Palestine conflict casualties”, “war mortality estimation”, and “household mortality surveys”. Before this study, mortality estimates for the Gaza conflict relied primarily on administrative records from the Gaza Ministry of Health (MoH), which some analysts have contested. Thus, independent assessment of the conflict’s death toll is needed, a gap partially filled by a capture–recapture analysis that used MoH data combined with social media obituaries to estimate 64 260 (95% CI 55 298–78 525) violent deaths to June, 2024. However, two of the three data sources in that analysis were components of the MoH database itself, restricting the study’s independence. No population-based household surveys had been conducted to provide fully independent mortality estimates for the Gaza conflict, and no empirically grounded estimates existed for non-violent excess deaths caused indirectly by the war.

#### Added value of this study

This study provides the first independent, population-based household survey estimate of mortality in Gaza during the current conflict. We surveyed 2000 households representing 9729 individuals and estimated 75 200 violent deaths (95% CI 63 600–86 800) and 8540 excess non-violent deaths (4540–12 500) between Oct 7, 2023, and Jan 5, 2025. The MoH

figure is 34.7% below our central estimate, closely aligning with the capture–recapture analysis, which found that the MoH figure was 39.1% below their estimate for their coverage period, providing rare cross-methodology validation. We found that 56.2% of violent deaths were among women, children, and older people (older than 64 years), consistent with MoH demographic reporting. The study showed that rigorous household mortality surveys are feasible even in extremely challenging conflict environments and challenges assumptions about inevitably high ratios of indirect to direct deaths in modern conflicts.

#### Implications of all the available evidence

The combined evidence suggests that, as of Jan 5, 2025, 3–4% of the population of the Gaza Strip had been killed violently and there have been a substantial number of non-violent deaths caused indirectly by the conflict. The validation of MoH reporting through multiple independent methodologies supports the reliability of its administrative casualty recording systems even under extreme conditions. The demonstration that household surveys remain feasible in active conflict zones should encourage similar data collection efforts in other conflicts where administrative systems might be compromised. These findings underscore the crucial importance of maintaining multiple, independent mortality estimation approaches and continued international monitoring of civilian casualties in conflict zones.

population-representative household survey conducted during the current Gaza conflict. Our aims were to: (1) provide an independent estimate of violent deaths; (2) assess the demographic composition of casualties; and (3) estimate non-violent excess mortality.

## Methods

### Study design and population

The GMS is a cross-sectional household survey designed to be representative of the population in the Gaza Strip before Oct 7, 2023. The survey was preregistered at OSF and received ethical approval from Royal Holloway, University of London (Egham, UK; ID 4317). All respondents provided oral informed consent.

At the time of fieldwork (Dec 30, 2024, to Jan 5, 2025), the Gaza Strip was divided into accessible and inaccessible zones due to ongoing military operations and Israeli-imposed restrictions on movement. Approximately 80–84% of Gaza’s population had been displaced at least once since Oct 7, 2023, with the majority concentrated in Khan Younis and Deir al-Balah Governorates. An estimated 449 000 to 494 000 people (20–22% of the pre-conflict population) remained in Northern Gaza, Gaza City, and Rafah, areas that were inaccessible to our field teams due to active combat and movement restrictions.<sup>10</sup> According to fieldwork done by The Palestinian Center for Policy and

Survey Research (PCPSR), displaced populations were living primarily in three types of accommodation: tent encampments (44.5% of accessible population), converted public buildings used as shelters such as schools and universities (20.5%), and remaining residential structures (35.0%). Mobile phone and internet connectivity remained functional in accessible areas, enabling real-time GPS tracking and team communication via WhatsApp throughout fieldwork.

PCPSR conducted data collection between Dec 30, 2024, and Jan 5, 2025. We surveyed households about household members who lived together on Oct 6, 2023, plus any children born subsequently. The survey covered the period from Oct 7, 2023, to Jan 5, 2025.

### Sampling design and procedures

We implemented a stratified two-stage cluster sample design. The sampling frame consisted of 2.23 million residents of the Gaza Strip distributed across five Governorates based on how the population was distributed before Oct 7, 2023: Northern Gaza (20.0%), Gaza City (33.6%), Khan Younis (19.7%), Deir al-Balah (14.3%), and Rafah (12.4%).

Widespread displacement and ongoing fighting in Northern Gaza, Gaza City, and Rafah made these areas inaccessible to field teams during data collection. Israeli

military operations had divided the Gaza Strip into distinct enclaves separated by military checkpoints and buffer zones, preventing civilian movement between these areas. However, PCPSR systematically tracked population movements throughout the conflict by coordinating with and using governmental sources such as municipal and social assistance authorities, the UN and UN Relief and Works Agency for Palestine Refugees in the Near East, international non-governmental organisations such as the Norwegian Refugee Council, satellite imagery analysis done by PCPSR, and ground verification by field teams. This tracking showed that most residents from inaccessible areas had been displaced to accessible regions in Khan Younis and Deir al-Balah Governorates, enabling us to sample these displaced populations. We therefore sampled across three dwelling-type strata within each of these two Governorates at the time of survey: (1) enumeration areas from the 2017 Palestinian census (35.0% of population), which included non-displaced people living in the Gaza Strip; (2) built-up shelters such as schools and universities (20.5%); and (3) tent gatherings (44.5%).

We selected 200 primary sampling units (PSUs) with probability proportionate to stratum size: 70 enumeration areas, 41 built-up shelter blocks, and 89 tent gathering blocks. For the 130 PSUs in shelters and tents, we sub-stratified by Governorate of residence before Oct 7, 2023. Interview teams screened households in these PSUs, only interviewing those from the designated inaccessible Governorate, ensuring representation of populations from Northern Gaza, Gaza City, and Rafah.

Within each PSU, we selected ten households using systematic random sampling. In enumeration areas, teams started from a random household and proceeded at fixed intervals. In shelters, teams randomly selected and then screened households until completing ten eligible interviews from the designated Governorate.

We interviewed one adult (aged 16 years or older) per household. This approach minimised non-response, because any competent adult could enumerate household members and their vital status. The response rate was 97.2%, with only 58 eligible households refusing participation out of 2058 approached (42 in shelters and 16 in enumeration areas).

### Questionnaire and data collection

We developed the questionnaire in English (appendix 2 pp 25–30). PCPSR translated it to Arabic, tested it on its own staff, and conducted a 1-day pilot in which two data collection teams interviewed 20 households in two different localities. The questionnaire first established a roster of household members as of Oct 6, 2023. For each person, respondents reported current vital status as one of the following: alive and resident, left Gaza Strip, moved within Gaza Strip, or dead, missing, or imprisoned. For deceased people,

respondents classified deaths as violent (killed in or because of fighting), non-violent (disease, pre-existing conditions, accidents, or other causes not directly related to combat) or unknown. The questionnaire also recorded births after Oct 6, 2023. In the questionnaire, respondents could report their gender as male or female.

Ten two-person teams, mostly female and highly experienced in survey interviews, conducted face-to-face interviews using tablets or mobile phones with ODK software version 2024.3.2. Four supervisors monitored fieldwork continuously and were present for at least a third of interviews. GPS tracking enabled real-time monitoring of team locations, ensuring team safety and verifying that fieldwork was near designated sampling sites. Completed interviews uploaded automatically to a secure central server accessible only to PCPSR researchers. Communication occurred via WhatsApp groups connecting all teams, supervisors, and the central research team. The security situation allowed teams to move freely within accessible areas of Khan Younis and Deir al-Balah throughout the survey period, although access to Northern Gaza, Gaza City, and Rafah remained impossible due to active military operations and movement restrictions.

Training emphasised that respondents should only report household members (those living together on Oct 6, 2023), not extended family members from other households. This method prevented double-counting deaths that might be reported by multiple related households.

### Statistical analysis

To adjust for deviations between sample and population distributions, we used raking, an iterative proportional fitting procedure that adjusts sample weights so that weighted sample distributions match known population marginal distributions across multiple characteristics simultaneously.<sup>11,12</sup>

We raked to four dimensions: (1) age and gender, using US Census Bureau International Database projections for the Gaza Strip;<sup>13</sup> (2) Governorate of origin, using Palestinian Central Bureau of Statistics projections;<sup>14</sup> (3) household size, using the Palestinian Multiple Indicator Cluster Survey 2019–20;<sup>15</sup> and (4) dwelling type at time of survey. We trimmed extreme weights to twice the median weight, although sensitivity analyses showed that trimming had a minimal effect. All analyses used the survey package (version 4.4-2) in R,<sup>16</sup> which accounts for the complex survey design. Our raking procedure adjusted estimates to match the pre-conflict population distribution by Governorate of origin. This approach implicitly assumes similar mortality rates between displaced and non-displaced households from the same Governorate of origin.

We calculated mortality estimates as weighted sums. Each individual in the sample received a weight representing the number of people in the Gaza Strip they

represent. The central estimate for violent deaths, for example, equals the sum of weights for all individuals reported as dying violently. We estimated crude mortality rates as deaths per 1000 population per year. We calculated crude death rates as the ratio of deaths to person–time exposure. Person–time contribution was assigned as: 1.00 for individuals who remained present throughout; 0.50 for those who died or left the Gaza Strip (assuming exposure occurred at the midpoint); and 0.25 for births who subsequently died or left the Gaza Strip.

We calculated excess non-violent deaths by subtracting projected baseline deaths from estimated non-violent deaths.<sup>17</sup> The US Census Bureau projected 6348 non-violent deaths for 2023, 6188 for 2024, and 6043 for 2025. Fieldwork was conducted from Dec 30, 2024, to Jan 5, 2025, with a median interview date of Jan 2, 2025 (IQR Dec 30, 2024, to Jan 4, 2025). We used the median date for baseline calculations. Prorating for days of conflict (86 in 2023, 366 in 2024, and two in 2025) yielded 7716 expected baseline non-violent deaths.

Because mortality estimates are non-linear functions under complex survey sampling, we used Taylor series linearisation to approximate variances for these functions.<sup>16</sup> The linearisation method approximates each ratio estimate as the true population ratio plus linear terms involving deviations in the numerator and

denominator. We calculated 95% CIs as the estimate plus or minus 1.96 times the SE.

We conducted six sensitivity analyses that varied model assumptions: excluding data from the highest-mortality team; using alternative household size adjustments; removing weight trimming; using Palestinian Central Bureau of Statistics instead of US Census Bureau population estimates; omitting household size adjustment; and using unadjusted data with equal probability weights. We also examined scenarios for mortality in inaccessible zones and missing people classification (appendix 2 pp 13–14).

### Role of the funding source

The funders had no role in data collection, analysis, interpretation, writing of the manuscript, or the decision to submit for publication.

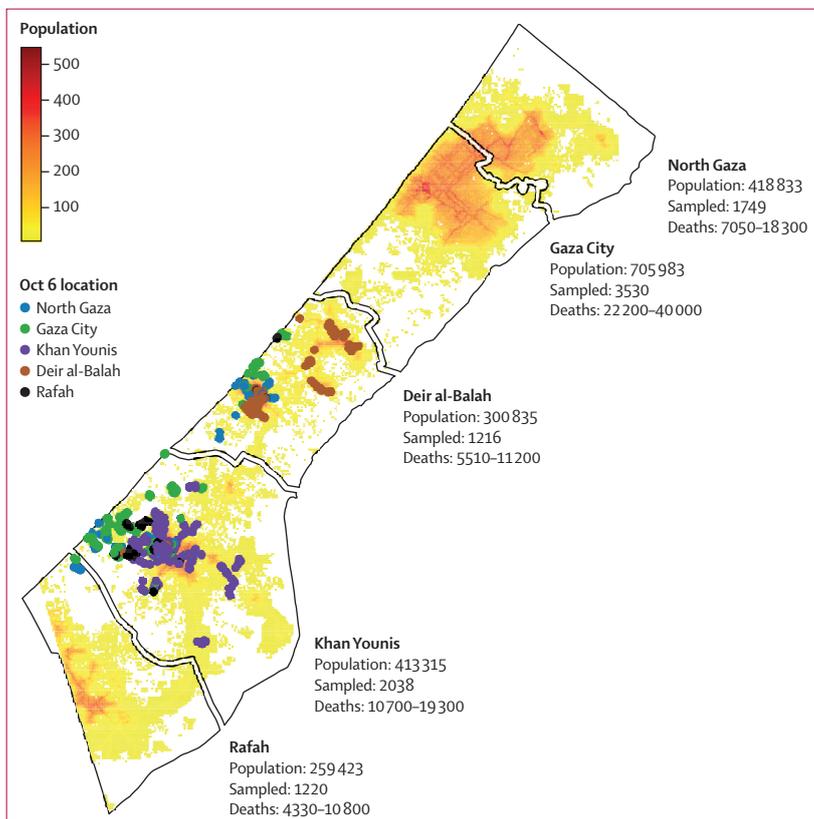
### Results

We completed 2000 household interviews out of 2058 households approached (97.2% household response rate), representing 9729 individuals who were household members on Oct 6, 2023. Item response rates were very high, with 100% completion for core demographic variables (age, gender, and vital status) and 99.8% completion for cause of death (460 of 461 deaths). The sample closely matched the pre-conflict population distribution by Governorate (figure). 1227 (61.4%) respondents were men and 773 (38.6%) were women. 242 (12.1%) respondents were aged 16–24 years, 641 (32.0%) were aged 25–34 years, 504 (25.2%) were aged 35–44 years, 339 (16.9%) were aged 45–54 years, and 274 (13.7%) were 55 years or older. Mean household size was 4.9 people (SD 2.2), slightly below the population figure of 5.5, possibly indicating successful training to exclude non-household relatives.

Table 1 shows outcomes for all individuals in the sample by gender and age. The survey recorded 357 births (179 boys and 178 girls) after Oct 6, 2023, of whom four infants (two boys and two girls) reportedly died. Of 9729 household members, 457 (4.7%) were reported dead (393 violent and 64 non-violent deaths; table 1), 62 (0.6%) were missing, 52 (0.5%) were imprisoned, 281 (2.9%) left the Gaza Strip, and 137 (1.4%) moved elsewhere within the Gaza Strip. Young adults (aged 18–29 years) made up the primary group leaving the Gaza Strip.

Deaths among male household members greatly outnumbered deaths among female household members aged 5–39 years. Men comprised 51 (98%) of 52 imprisoned individuals. Missing people were predominantly male across all age categories, especially ages 18–39 years (table 2).

Table 3 shows violent deaths by Governorate of origin. Within-sample violent death rates were highest in Gaza City (4.5%), followed by Rafah (3.8%), Khan Younis



**Figure:** Sampling points by location of respondents with further information on the sample and estimates, colour-coded for governorate of origin

	Present		Left Gaza Strip		Moved out of household		Dead		Missing		Imprisoned		Total
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
0–4 years	509	441	5	1	0	0	8	10	1	0	0	0	975
5–11 years	757	679	12	13	3	4	27	17	2	2	0	0	1516
12–17 years	534	581	11	13	2	3	31	12	7	2	0	0	1196
18–29 years	1015	1277	65	53	30	33	106	53	27	0	21	0	2680
30–39 years	631	635	24	30	20	6	52	20	14	0	23	0	1455
40–64 years	817	721	22	28	24	8	42	43	6	1	6	1	1719
Older than 64 years	81	62	0	4	2	2	17	19	0	0	1	0	188
Total	4344	4396	139	142	81	56	283	174	57	5	51	1	9729

Data are unweighted and were collected using the Gaza Mortality Survey.

**Table 1: Outcomes for all people in the sample, classified by gender and age group**

(3·6%), Northern Gaza (3·5%), and Deir al-Balah (2·8%; figure).

We estimated 12 200 people to be missing (95% CI 7900–16 500), predominantly men aged 18–64 years (8470 [95% CI 5240–11 700]) and children (3610 [1570–5650]; appendix 2 p 6). 3741 (30·6%) of the 12 200 estimated missing people were women, children, and older people (older than 64 years; 95% CI 18·1–43·2). It remains unclear what proportion of missing people could be deceased (see appendix 2 p 14 for alternative scenarios).

Table 4 presents crude mortality rates. We estimated a crude mortality rate from violence of 33·1 per 1000 population per year (95% CI 27·9–38·4) and a crude non-violent death rate of 7·2 per 1000 population per year (5·40–8·93), for a total crude death rate of 40·3 per 1000 population per year (34·6–46·0).

Table 5 presents the main mortality estimates after raking and weighting adjustments. We estimated that 75 200 violent deaths (95% CI 63 600–86 800) occurred between Oct 7, 2023, and Jan 5, 2025, representing 3·4% of the Gaza Strip’s pre-war population. Among violent deaths, we estimated that 22 800 were children younger than 18 years (95% CI 16 700–28 800), 16 600 were women aged 18–64 years (12 200–20 900), 2870 were people older than 64 years (1020–4720), and 32 900 were men aged 18–64 years (27 600–38 200). Women, children, and older people together comprised 56·2% of violent deaths (95% CI 50·4–61·9), totalling 42 200 deaths (95% CI 33 100–51 300).

We estimate 16 300 total non-violent deaths (95% CI 12 300–20 200). Subtracting 7716 projected baseline deaths yielded 8540 excess non-violent deaths (95% CI 4540–12 500).

The MoH reported approximately 49 090 violent deaths for the same period. This figure is 34·7% below our central estimate of 75 200, and 22·8% below the lower bound of our 95% CI. However, the MoH’s reported percentage of women, children, and older people among deaths (54·0%) closely matches our estimate of 56·2%.

	Non-violent		Accident		Violent		Total
	Male	Female	Male	Female	Male	Female	
0–4 years	0	2	0	0	8	8	18
5–11 years	2	0	2	1	23	16	44
12–17 years	0	1	0	0	31	11	43
18–29 years	2	0	0	0	104	53	159
30–39 years	0	1	1	0	51	19	72
40–64 years	8	17	0	0	34	26	85
Older than 64 years	9	17	1	0	7	2	36
Total	21	38	4	1	258	135	457

Data are unweighted and were collected using the Gaza Mortality Survey.

**Table 2: All deaths in the sample, classified by gender and age group**

	Violent deaths	Violent deaths as percentage of sample
Northern Gaza	68	3·9%
Gaza City	164	4·7%
Deir al-Balah	39	3·2%
Khan Younis	87	4·3%
Rafah	35	2·9%

Data are unweighted and were collected using the Gaza Mortality Survey.

**Table 3: All violent deaths in the sample, classified by governorate of origin**

	Crude death rate	SE (95% CI)
Violent	33·1	8·0 (27·9–38·4)
Non-violent	7·2	2·7 (5·4–8·9)
Total	40·3	8·7 (34·6–46·0)

Estimates are raked (adjusted using iterative proportional fitting) to match known population distributions across age, gender, governorate, and household size. Calculations made from the Gaza Mortality Survey household roster, the Gaza Mortality Survey births file, and the International Database US Census Bureau population estimates.

**Table 4: Crude death rate per 1000 population per year for violent and non-violent deaths**

	Estimate	SE (95% CI)
<b>Violent deaths</b>		
Children younger than 18 years	22 800	3090 (16 700–28 800)
Women aged 18–64 years	16 600	2220 (12 200–20 900)
People older than 64 years	2870	943 (1020–4720)
Men aged 18–64 years	32 900	2700 (27 600–38 200)
Women, children, and older people	42 200	4630 (33 100–51 300)
Total violent deaths	75 200	5920 (63 600–86 800)
Proportion of violent deaths among women, children, and older people (%)	56.2%	2.94 (50.4–61.9)
<b>Non-violent deaths</b>		
Total non-violent deaths	16 300	2040 (12 300–20 200)
Excess non-violent deaths	8540	2040 (4540–12 500)

Estimates are raked (adjusted using iterative proportional fitting) to match known population distributions across age, gender, governorate, and household size. Based on Gaza Mortality Survey household roster and births.

**Table 5: Estimates of violent and non-violent mortality by broad age and gender groups**

Seven sensitivity analyses tested the robustness of estimates to model assumptions (appendix 2 p 7). Five analyses produced results that were similar to the main model. Only two yielded substantially different estimates. Excluding data from the team recording the most deaths (100 of 393 deaths) reduced the violent death estimate to 64 100 (95% CI 54 100–74 100). Investigation revealed that this team covered three PSUs in shelters prioritising families with casualties and five PSUs in heavily attacked areas, suggesting sampling variation rather than data quality issues. Comparison of interviews with and without supervisors for this team revealed no discrepancies, supporting the quality of the data. Using unadjusted equal-probability weights (no raking) increased the violent death estimate to 85 200 (95% CI 71 800–98 600) and decreased the percentage of women, children, and older people to 52.2%, reflecting over-representation of men and small households in the raw sample.

## Discussion

This first population-representative survey had three main findings. First, violent deaths substantially exceeded official MoH figures, with an estimated 3.4% of the Gaza Strip's population killed up to early January, 2025. Second, women, children, and older people comprised 56.2% of violent deaths, consistent with MoH reporting. Third, although non-violent excess deaths were substantial (ie, 8540), they were far lower than some projections<sup>7,8</sup> and did not exceed violent deaths.

Our finding that MoH figures undercount violent deaths by approximately 35% closely aligns with the capture–recapture estimates of Jamaluddine and colleagues,<sup>5</sup> who found an undercount of approximately 40% using completely different methods. This rare validation between survey and capture–recapture methodologies<sup>18</sup> strengthens confidence in both approaches, with the capture–recapture method increasingly used to measure deaths as a result of conflict.<sup>19,20</sup>

Our findings contradict claims that the MoH has inflated the death toll from the war in the Gaza Strip.<sup>4</sup> Instead, the MoH appears to provide conservative, reliable figures while working under extraordinary constraints. Our estimates are also incompatible with projections that indirect deaths are at least four times higher than violent deaths<sup>7</sup> or that 62 413 people died of starvation.<sup>8</sup> Although subsequent conditions worsened, our data to early January, 2025, show that violent deaths outnumbered non-violent deaths.

Our excess mortality estimate might appear inconsistent with reports of very high mortality among specific vulnerable groups, such as the finding that approximately 40% of patients on dialysis died or left the Gaza Strip.<sup>21</sup> However, such groups represent small fractions of the pre-conflict population of the Gaza Strip, which was approximately 2.2 million people.<sup>17</sup> Even if there were 1000–2000 patients on dialysis and a 40% mortality rate, this would contribute 400–800 excess deaths, which is consistent with our population-level estimate of 8540. Similar patterns probably exist for other medically vulnerable subgroups, each with elevated mortality but little effect on overall excess deaths due to small population sizes.

A high ratio of indirect to direct deaths is not inevitable in warfare. The Kosovo Memory Book classified only 281 of 13 517 deaths in the 1998–99 war as indirect.<sup>22</sup> In Yemen's 2015–19 civil war, although overall mortality increased by 17.8% above baseline, direct combat accounted for 67.2% of excess deaths.<sup>23</sup> In Darfur (2003–08), crude mortality rates varied substantially by period, ranging from 0.49 to 5.86 per 10 000 per day depending on the intensity of conflict.<sup>3</sup> In Tigray (2020–23), conflict-attributable child mortality rates increased during active conflict but showed considerable variation by age group and time period.<sup>24</sup> These examples show that patterns vary considerably across conflicts even in challenging humanitarian conditions, with the ratio of indirect to direct deaths depending on conflict characteristics, humanitarian access, and baseline health conditions.

This study's main strength was data collection using rigorous survey methodology in an active conflict zone, which was previously claimed to be unfeasible.<sup>5</sup> The high household response rate (97.2%; 2000 completed interviews out of 2058 attempted) with near-complete (99.8%) item response across core mortality variables, GPS tracking, supervisor monitoring, and systematic sampling procedures enhanced data quality. The close match between our demographic findings and MoH reports provides external validation.

Several limitations merit consideration. First, we could not sample households with zero remaining live members or no members who were 16 years or older. Although documented,<sup>25</sup> the prevalence of such households is unknown, introducing potential underestimation. Second, we could not reach the population remaining in Northern Gaza, Gaza City, or

Rafah (described in the Methods section), representing a substantial proportion of overall person-time. Although many displaced households experienced violence during displacement, and we sampled extensively among displaced populations, this gap probably contributes to underestimation, particularly for non-violent deaths given restricted humanitarian access to northern areas. Sensitivity analysis (appendix 2 p 13) suggested that, if these zones had elevated mortality, our estimates could increase by 7–27% under plausible scenarios.

Third, respondents from Deir al-Balah and Khan Younis who were displaced to shelters fell outside our sampling frame, which used shelters exclusively for households from inaccessible Governorates. We implicitly assumed equal mortality between displaced and non-displaced households from these Governorates, although displaced households probably experienced higher mortality. Fourth, Governorate-specific violent death rates should be interpreted cautiously because many displaced people died outside their Governorate of origin, and we did not collect information on death location. Fifth, the raw sample over-represented men and small households. Raking adjustments were necessary to account for these imbalances and bring estimates closer to population parameters. Sixth, proxy reporting could introduce misclassification, although this is standard in mortality surveys and respondent characteristics probably influence recall accuracy.

Seventh, respondents might have over-reported deaths. However, our roster-then-status procedure limited post-hoc additions, teams communicated no material benefit from participation, and the mean household size of our sample (4.9 people [SD 2.2]), which was below the population figure (5.5), argues against inflation with non-household relatives. Finally, the vital status of missing people (12 200 estimated) remains unclear, with implications for overall mortality and demographic composition. We have no empirical basis to estimate what proportion of missing people could be deceased versus displaced without communication, detained in undocumented circumstances, or other scenarios. Our main estimates conservatively treat all missing people as alive. Even under the extreme and implausible assumption that all missing people are deceased, our key demographic finding remains robust: women, children, and older people would comprise 52.2% rather than 56.2% of deaths, still showing patterns consistent with MoH reporting (appendix 2 p 14).

The net direction of bias in our estimates is uncertain, with multiple offsetting factors potentially leading to either underestimation or overestimation. Our figures represent point estimates with associated uncertainty, not definitive counts. Confidence intervals reflect statistical uncertainty from sampling but do not capture systematic biases or uncertainty in baseline mortality projections. Readers should view confidence intervals as indicative ranges rather than comprehensive bounds.

This survey shows the feasibility of mortality surveillance even in extraordinarily challenging active conflict settings. The success highlights the need for systematic mortality surveillance in conflict zones globally.

The MoH's casualty recording work provides value extending far beyond aggregate numbers. By naming individual victims, the MoH endows each person with human dignity.<sup>26</sup> This memorialisation project must continue for years after the war ends. Estimates like ours can guide casualty recording but cannot provide each human being due recognition in death.

Since data collection ended, humanitarian conditions have deteriorated substantially. A fragile ceasefire began 10 days after our survey but collapsed with renewed Israeli airstrikes on March 18, 2025. Six senior UN officials warned of looming humanitarian catastrophe on April 7, 2025.<sup>27</sup> In August, 2025, the Integrated Food Security Phase Classification declared Gaza City to be in Phase 5 famine, the most severe food security emergency.<sup>28</sup> The ratio of non-violent to violent deaths has probably increased since our data collection period. Moreover, past research suggests that the long-term health toll of conflicts accumulates over years even after acute violence ends.<sup>29,30</sup> Continued MoH surveillance and independent surveys remain essential for understanding the evolving dynamics of death.

This first independent population survey of mortality from the conflict in the Gaza Strip establishes that violent deaths have substantially exceeded official figures whereas demographic patterns align with official reports. Non-violent excess deaths, although substantial, do not approach some projections. These results underscore the feasibility of mortality surveillance in highly challenging conflict settings and provide a crucial empirical foundation for assessing the true human cost of the conflict.

#### Contributors

MS, DG-S, and JP conceived the project. DG-S and HH secured funding. MS, DG-S, JP, KS, and MR conducted survey planning. KS and MR drafted sampling and fieldwork descriptions. All authors monitored data collection. JP, MS, KS, and EB conducted statistical analysis. MS wrote the first draft with input from EB. All authors contributed to, reviewed, and approved the manuscript, accessed and verified underlying data, and take responsibility for data integrity and analysis accuracy. MS takes responsibility for the decision to submit for publication.

#### Declaration of interests

KS is the Director of the PCPSR, which conducted the fieldwork for the study and received payment for these services. All other authors declare no competing interests.

#### Data sharing

All data and code are publicly available and can be accessed at <https://gitfront.io/r/mspagat/tZwP79d7Pntz/Gaza-Mortality-Survey/>

#### Acknowledgments

We thank Walid Ladadweh for supervising sample selection and field team deployment, and the anonymous data collection teams who worked under extraordinarily difficult conditions in the Gaza Strip. This work was supported by European Research Council Grant 101055176, ANTICIPATE, and the Center for Research on the Epidemiology of Disaster at Université Catholique de Louvain. During manuscript

revision, MS used Claude AI to assist with editing and referee response preparation. After using Claude AI, we reviewed and edited the content as needed and take full responsibility for the content of the publication.

#### References

- 1 Spiegel PB, Salama P. War and mortality in Kosovo, 1998–99: an epidemiological testimony. *Lancet* 2000; **355**: 2204–09.
- 2 Alkhuzai AH, Ahmad IJ, Hweel MJ, et al, and the Iraq Family Health Survey Study Group. Violence-related mortality in Iraq from 2002 to 2006. *N Engl J Med* 2008; **358**: 484–93.
- 3 Degomme O, Guha-Sapir D. Patterns of mortality rates in Darfur conflict. *Lancet* 2010; **375**: 294–300.
- 4 Fox A. Questionable counting: analysing the death toll from the Hamas-run Ministry of Health in Gaza. London: Henry Jackson Society, 2024.
- 5 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; **405**: 469–77.
- 6 Guillot M, Draidi M, Cetorelli V, Monteiro Da Silva JHC, Lubbad I. Life expectancy losses in the Gaza Strip during the period October, 2023, to September, 2024. *Lancet* 2025; **405**: 478–85.
- 7 Khatib R, McKee M, Yusuf S. Counting the dead in Gaza: difficult but essential. *Lancet* 2024; **404**: 237–38.
- 8 Gaza Healthcare Letters. Letter to President Biden and Vice President Harris. 2024. <https://www.gazahealthcareletters.org/usa-letter-oct-2-2024> (accessed Jan 15, 2025).
- 9 Médecins Sans Frontières (Doctors Without Borders). MSF survey of staff and their families in Gaza shows almost half of those killed in war were children. 2024. <https://www.doctorswithoutborders.org/latest/msf-survey-staff-and-their-families-gaza-shows-almost-half-those-killed-war-were-children> (accessed Jan 15, 2025).
- 10 UN Office for the Coordination of Humanitarian Affairs. Population and internal displacement 7 October 2023—Gaza Strip. 2024. <https://www.ochaopt.org/content/population-and-internal-displacement-7-october-2023-gaza-strip> (accessed Jan 15, 2025).
- 11 Cohen MP. Raking. In: Lavrakas PJ, ed. *Encyclopedia of survey research methods*. Thousand Oaks, CA: Sage Publications, 2008: 672–73.
- 12 Dorofeev S, Grant P. *Statistics for real-life sample surveys: non-simple-random samples and weighted data*. Cambridge: Cambridge University Press, 2006.
- 13 US Census Bureau. International database—age tables. 2025. <https://www.census.gov/data-tools/demo/idb/> (accessed Jan 25, 2025).
- 14 Palestinian Central Bureau of Statistics. Estimated population in Palestine mid-year by governorate, 1997–2026. 2021. [https://www.pcbs.gov.ps/statisticsIndicatorsTables.aspx?lang=en&table\\_id=676](https://www.pcbs.gov.ps/statisticsIndicatorsTables.aspx?lang=en&table_id=676) (accessed Dec 15, 2024).
- 15 UNICEF. State of Palestine, MICS 2019–20 dataset. 2021. <https://mics.unicef.org/surveys?display=card&keys=State%20of%20Palestine> (accessed Jan 11, 2026).
- 16 Lumley T, Gao P, Schneider B. Survey: analysis of complex survey samples. 2024. <https://cran.r-project.org/web/packages/survey/> (accessed Jan 11, 2026).
- 17 US Census Bureau. International database—death projections. 2025. <https://www.census.gov/data-tools/demo/idb/> (accessed Jan 25, 2025).
- 18 Spagat M. A triumph of remembering: Kosovo Memory Book. 2014. [http://www.kosovomemorybook.org/wp-content/uploads/2015/02/Michael\\_Spagat\\_Evaluation\\_of\\_the\\_Database\\_KMB\\_December\\_10\\_2014.pdf](http://www.kosovomemorybook.org/wp-content/uploads/2015/02/Michael_Spagat_Evaluation_of_the_Database_KMB_December_10_2014.pdf) (accessed Jan 15, 2025).
- 19 Human Rights Data Analysis Group, Commission for the Clarification of Truth Coexistence and Non-Repetition, Special Jurisdiction for Peace. Methodological report of the JEP-CEV-HRDAG joint project on data integration and statistical estimation. 2025. <https://hrdag.org/CEV-JEP/20250306-methodological-report-EN.pdf> (accessed Jan 11, 2026).
- 20 Dahab M, AbuKoura R, Checchi F, et al. War-time mortality in Sudan: a multiple systems estimation analysis. *Lancet Glob Health* 2025; **13**: e1583–90.
- 21 Aldabbour B, Elhissi AJH, Abuwarda M, et al. Quality of life and access to healthcare among hemodialysis patients during wartime: cross-sectional insights from Gaza. *BMC Nephrol* 2025; **26**: 367.
- 22 Humanitarian Law Center, Humanitarian Law Center Kosovo. Kosovo Memory Book: database of victims killed or missing in connection with the war in Kosovo (1998–2000). 2014. <https://www.hlc-rdc.org/en/loss-database/kosovo-memory-book/> (accessed Jan 11, 2026).
- 23 Guha Sapir D, Ogbu JT, Scales SE, et al. Civil war and death in Yemen: analysis of SMART survey and ACLED data, 2012–2019. *PLOS Glob Public Health* 2022; **2**: e0000581.
- 24 McGowan CR, Cassidy-Seyoum SA, Ekoriko P, et al. Conflict-attributable mortality in Tigray Region, Ethiopia: evidence from a survey of the Tigrayan diaspora. *Popul Health Metr* 2025; **23**: 19.
- 25 Deeb SE. The war in Gaza is wiping out entire Palestinian families, one branch at a time. This is how. 2024. <https://apnews.com/article/gaza-palestinians-families-deaths-israeli-strikes-79f2cb7f3b04c512092f59f327443732> (accessed Jan 15, 2025).
- 26 Every Casualty Counts. What is casualty recording? <https://everycasualty.org/what-is-casualty-recording/> (accessed Oct 10, 2025).
- 27 UNOPS. Joint UN statement: world must act with urgency to save Palestinians. 2025. <https://www.unops.org/news-and-stories/speeches/joint-un-statement-world-must-act-with-urgency-to-save-palestinians-in-gaza> (accessed April 10, 2025).
- 28 Integrated Food Security Phase Classification. IPC Famine Review Committee report: Gaza Strip (August 2025). 2025. [https://www.ipcinfo.org/fileadmin/user\\_upload/ipcinfo/docs/IPC\\_Famine\\_Review\\_Committee\\_Report\\_Gaza\\_Aug2025.pdf](https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Famine_Review_Committee_Report_Gaza_Aug2025.pdf) (accessed Jan 11, 2026).
- 29 Ghobarah HA, Huth P, Russett B. Civil wars kill and maim people—long after the shooting stops. *Am Polit Sci Rev* 2003; **97**: 189–202.
- 30 Wagner Z, Heft-Neal S, Bhutta ZA, Black RE, Burke M, Bendavid E. Armed conflict and child mortality in Africa: a geospatial analysis. *Lancet* 2018; **392**: 857–65.