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Fetal and early neonatal outcomes among facility-based maternal deaths in Luapula Province, Zambia (2019-2025): a retrospective cohort study

Charles Kabwebwe[1]

charleschongokabwebwe@gmail.com

Lusaka Apex Medical University

Kingford Chimfwembe[2]

Lusaka Apex Medical University

Sampa Namwawa[2]

Lusaka Apex Medical University

Kasakula N Kaunda[1]

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Abstract

Background

When a woman dies in pregnancy or childbirth, her fetus or newborn frequently dies with her. Maternal and perinatal deaths are recorded in separate surveillance streams, so the fate of the infant after a maternal death is rarely quantified. No local estimate existed for Luapula Province, Zambia, where island and swamp communities depend on water transport for referral.

Methods

Retrospective cohort study of all facility-based maternal deaths recorded in the provincial Maternal Death Surveillance and Response system in Luapula Province, 2019–2025, triangulated against maternity and neonatal registers. The primary outcome was stillbirth versus live birth and the secondary outcome early neonatal death. Proportions were compared with chi-square and Fisher exact tests, and independent predictors examined in three nested multivariable logistic regression models. An exploratory linkage to the province's separate perinatal-death register (2024–2025) was performed.

Results

Of 233 maternal deaths analysed (91% of provincially reported deaths), 117 (50.2%) ended in a live birth. Among 211 determinable fetal outcomes the stillbirth rate was 25.6% (54/211); fresh stillbirths outnumbered macerated 3.5:1, with no trend over seven years ($p = 0.40$). Stillbirth was highest after hypertensive or malarial maternal deaths (33.3% each) and intermediate after haemorrhage (28.2%), the commonest cause. Antenatal attendance was not associated with stillbirth (24.5% versus 23.7% for fewer than four visits; $p = 0.91$). Island and mainland outcomes did not differ, but only nine island cases were recorded. No factor was robustly significant in adjusted models; maternal age was the most consistent signal (adjusted odds ratio 1.08 per year, 95% CI 1.00-1.17, $p = 0.060$) and models explained little variance (pseudo-R^2 0.03–0.07). Early neonatal follow-up was documented for fewer than 1% of cases; the estimate of 7.7% early neonatal death is certainly an undercount.

Conclusions

One fetus in four died alongside its mother in Luapula, predominantly around labour, with no improvement over seven years. The fresh-dominant pattern implicates delay in care after reaching a facility. Surveillance loses sight of the infant at birth, so the survivor deficit cannot be measured. Perinatal outcomes should be recorded in every maternal death review, and the maternal and perinatal surveillance streams should share a common identifier.

Background

A newborn's survival is inseparable from its mother's. When a woman dies from a complication of pregnancy or childbirth, her infant frequently dies too, at birth or in the days that follow [1]. The newborn period is the most dangerous stretch of childhood everywhere in the world: in 2020 there were an estimated 0.3 million maternal deaths, 1.9 million stillbirths and 2.4 million neonatal deaths, with causes that overlap so heavily they can only be understood together [1–2]. Progress against newborn death has lagged behind progress against death in older children, and roughly a third of neonatal deaths occur on the day of birth with almost three-quarters within the first week - a timing that points directly at labour, delivery and the quality of obstetric care [3–4].

The burden is grossly unequal. A woman in sub-Saharan Africa faces a lifetime risk of maternal death of about 1 in 37 [5], and the conditions that kill mothers - severe haemorrhage, hypertensive disease, sepsis - are largely the same conditions that kill their infants [6–7]. Systematic review evidence indicates that the death of a mother sharply raises the risk of death for her child, with the excess concentrated in the first weeks of life [8–10]. Yet surveillance systems still tend to record the two deaths in separate ledgers, so that when a mother dies, what becomes of her baby quietly drops out of view [11–12].

Zambia has invested heavily in maternal and child health through successive national health strategic plans and a sustained push for facility delivery [13]. Maternal mortality has fallen, but newborn survival has not kept pace - the quality-coverage gap in which higher facility-delivery coverage fails to translate into better outcomes because the care received is not good enough [14–15]. The national neonatal mortality rate remains approximately 27 per 1,000 live births [16], and neonatal death is concentrated in rural provinces with limited access to tertiary care [17].

Luapula Province is a revealing setting in which to examine this problem. Its geography is unusual: districts such as Lunga consist of islands and swamp channels with no road access, where every referral depends on a boat and time is lost on open water. Distance and level of care are known determinants of delivery place and perinatal outcome in rural Zambia [18], and qualitative work in Luapula itself has documented how women in these communities experience and anticipate access to delivery care [19–20]. Provincial infrastructure is thin, with rural facilities short of skilled midwives and basic commodities and neonatal intensive care confined to the provincial capital [21]. Above all, no local data existed on what happens to the infants of women who die in the maternal period, so the response half of maternal and perinatal death surveillance and response (MPDSR) had little on which to act.

This study therefore treats the mother and infant as a single unit of analysis, consistent with the MPDSR framework [12, 22]. Its objectives were: (i) to determine fetal and early neonatal survival among documented facility-based maternal deaths in Luapula Province between 2019 and 2025; (ii) to compare outcomes between island and mainland facilities; and (iii) to identify the maternal, obstetric and facility-level factors associated with fetal survival.

Methods

Study design and setting

We conducted a retrospective cohort study based on secondary analysis of routine surveillance and facility records - in effect a structured record review - and report it in accordance with the STROBE statement for observational studies [23] (Additional file 1). The study covered all districts of Luapula Province, Zambia. Mansa General Hospital is the provincial tertiary referral centre; St Paul's Mission Hospital in Nchelenge serves the northern districts and the island communities of Lake Mweru. Lunga District has only rural health centres and health posts on islands in the Bangweulu Swamps, with no road access, and its referrals travel by boat to Samfya or Chilubi, where the transfer from water to road transport can decide whether care arrives in time.

Population, case definition and eligibility

Maternal death was defined according to ICD-MM as the death of a woman while pregnant or within 42 days of the end of pregnancy, from any cause related to or aggravated by the pregnancy or its management [24]. Stillbirth was defined as fetal death at 28 completed weeks or more, or a birth weight of 1,000 g or more; fresh stillbirth denoted intact skin implying intrapartum death and macerated stillbirth denoted skin peeling or discolouration implying antepartum death. Early neonatal death was death of a live-born infant within the first seven completed days of life. An island facility was one on an island in Lake Bangweulu, Lake Mweru or the Bangweulu Swamps, reachable only by water.

We included all facility-based maternal deaths recorded in Luapula between 1 January 2019 and 31 December 2025 for which pregnancy outcome data were available. We excluded deaths from accidental or incidental causes unrelated to pregnancy management, and community-based maternal deaths. Community deaths were excluded because their infant outcomes cannot be tied to an auditable record trail comparable to facility MDSR and maternity or neonatal registers; this exclusion is likely to understate the true perinatal burden, particularly in remote island areas, and is revisited in the limitations. Because maternal deaths are rare, we used complete enumeration of all eligible cases rather than sampling [22].

Data sources and abstraction

The primary data source was the provincial MDSR system held at the Luapula Provincial Health Office in Mansa, triangulated against maternity-ward and neonatal-unit registers at contributing facilities. A structured Open Data Kit instrument captured maternal demographics, obstetric history (including antenatal visits and HIV status), the maternal event and its cause, infant outcomes, and system factors including referral pathway, facility level and island versus mainland location. Each maternal death received an anonymous study identifier at extraction; operational MDSR identifiers were kept on a

separate encrypted linkage log accessible only to the principal investigator and destroyed once the dataset was locked.

Abstractors matched each maternal event to its maternity-register line by date, facility, parity or age and clinical narrative, following a written standard operating procedure; discordant matches went to senior review and non-linkable rows were logged with a reason. The instrument was pilot-tested at one facility before roll-out, which exposed ambiguous free-text fields for pregnancy outcome and cause of death; these were given closed response options and explicit coding rules before the main abstraction. At least 10% of records were independently double-abstracted, with agreement quantified and any discrepancy affecting outcome classification resolved by consensus with a clinician supervisor. Every cause of death was standardised to the ICD-MM classification. Abstraction took place on site only, in secure rooms, and registers never left the premises.

Data preparation and quality assurance

Because two of the exposures of interest had been lost during intermediate data handling, a documented recovery step was undertaken before analysis. Gestational age and antenatal-care attendance were present in the original line lists (in approximately 95% and 85% of records respectively) but absent from the working dataset. Both were recovered by matching each case back to its source record - by serial number for 2019–2023 and by a composite key of age, parity and gravidity for 2024–2025 - raising gestational-age completeness from 30% to 89% (207/233) and creating an antenatal-care variable for 80% of cases (186/233). Recovered values were validated against the records the working dataset had retained, with 66 of 70 agreeing exactly.

The recovered gestational age required cleaning. Five cases recorded as live births below 24 weeks, below the threshold of viability, had gestational age set to missing while the live-birth outcome was retained. Eight cases recorded as fresh or macerated stillbirths below 28 weeks breached the study's stillbirth definition and were reclassified as abortion or intrauterine fetal death in line with that definition. These corrections are the reason the stillbirth rate reported here (25.6%) is lower than an uncorrected count would give (28.3%); all changes were logged and are auditable. Two non-case administrative entries - a record dated 2026 and a district-total summary row - were removed, and district fields mixing hospitals, wards and out-of-province sites were harmonised to the twelve canonical Luapula districts. Data were managed in Python (pandas, numpy) and Stata 17 on encrypted devices, with a weekly 5% audit of new records by the principal investigator.

Statistical analysis

The primary outcome was the binary fetal outcome, stillbirth versus live birth, analysed among cases with a determinable outcome. The secondary outcome was early neonatal survival, defined as being alive through the seventh completed day (168 hours). Descriptive statistics report frequencies and proportions for maternal characteristics and infant outcomes. Groups were compared using the chi-

square test, or the Fisher exact test where expected cell counts were small, and trend across 2019–2025 was assessed with the Cochran-Armitage test. Three nested multivariable logistic regression models were fitted: a core model adjusting for maternal age, parity, referral status and island residence; a second adding antenatal-care attendance; and a third adding gestational age in weeks. Models used complete cases for the variables entered, and the analysed denominator is reported for each. Missingness is reported per variable. Statistical significance was set at $p < 0.05$, and effect estimates are presented as odds ratios with 95% confidence intervals.

Exploratory linkage to the perinatal-death register

To probe the early-neonatal gap, an exploratory probabilistic linkage was attempted between the maternal cohort and the province's separate perinatal-death register. The register was available for 2024–2025 only and captures all perinatal deaths in the province rather than only those of mothers who died. No shared identifier exists between the two systems, so linkage used district, mother's initials and an infant birth date within seven days of the maternal death. This was feasible only for the 34 maternal deaths in 2025 that recorded maternal initials; 2024 records used bare serial numbers and could not be name-matched. Results of this linkage are presented as exploratory and indicative, not confirmatory.

Ethics

Ethical approval

was granted by the Lusaka Apex Medical University Bio-Medical Research Ethics Committee (LAMUBREC No. 08019/07/04/2026, 7 April 2026) and authority to conduct the research by the Zambian National Health Research Authority (NHRA-3643/26/05/2026, 10 June 2026). Gatekeeper permission was obtained from the Luapula Provincial Health Office and each participating facility. A waiver of individual informed consent was granted, on the grounds that the research depends on historical records, most subjects are deceased, the study carries only minimal informational risk mitigated by de-identification at extraction, and it serves a clear public-health purpose. Handling of data was consistent with Zambia's Data Protection Act.

Results

Cohort characteristics

After exclusion of two non-case administrative entries, 233 facility-based maternal deaths were available for analysis. For context, the provincial MPDSR aggregate summary recorded 257 maternal deaths over the same period, so the case-level line lists analysed here capture approximately 91% of all maternal deaths counted at provincial level; the shortfall was modest in most years but concentrated in 2023 (36 line-listed against 50 in the aggregate summary). Table 1 summarises the cohort. Deaths were concentrated in Mansa District (64.4%), the seat of the provincial referral hospital and the most populous district. Only nine cases (3.9%) originated from island communities. Almost nine in ten women (87.6%)

had been referred from a lower-level facility, confirming that this is a tertiary, end-of-pathway sample. Women were young (mean age 28.1 years, SD 7.3, range 14–48) and parity was high (mean 3.1, range 0–11). Gestational age was available for 207 cases (89%; median 36 weeks, IQR 32–38) and number of antenatal visits for 186 (80%; median 3).

Table 1
Sociodemographic and obstetric characteristics of 233 facility-based maternal deaths, Luapula Province, Zambia, 2019–2025

Characteristic	n	% or mean ± SD
District of death		
Mansa	150	64.4
Nchelenge	21	9.0
Samfya	17	7.3
Other districts	45	19.3
Geographic setting		
Island	9	3.9
Mainland	224	96.1
Admission route		
Referred from another facility	204	87.6
Direct admission	29	12.4
Maternal age, years	223	28.1 ± 7.3 (median 28; range 14–48)
Parity	232	3.1 ± 2.6 (range 0–11)
Gravidity	232	3.9 ± 2.8
Antenatal visits	186	median 3 (80% complete)
Gestational age, weeks	207	median 36 (IQR 32–38; 89% complete)

SD standard deviation, IQR interquartile range. Denominators vary because of item-level missingness, which is reported for each variable.

Pregnancy outcomes

Pregnancy outcomes fell into eight categories drawn from register entries and clinical notes (Table 2, Fig. 1). A live birth was documented in 117 of 233 cases (50.2%). Among outcomes in which fetal viability could be judged with reasonable confidence (n = 211), 54 were stillbirths, a stillbirth rate of 25.6%. Fresh stillbirths outnumbered macerated stillbirths 42:12, a ratio of approximately 3.5:1,

indicating that most fetal deaths occurred around the time of labour or shortly before arrival rather than days earlier.

Table 2
Distribution of pregnancy outcomes among 233 facility-based maternal deaths

Outcome	n	% of all cases	% of determinable outcomes
Live birth	117	50.2	55.5
Fresh stillbirth	42	18.0	19.9
Macerated stillbirth	12	5.2	5.7
Abortion / intrauterine fetal death	21	9.0	-
Undelivered at death	10	4.3	-
Non-specific 'dead'	13	5.6	-
Unknown / not recorded	14	6.0	-
Other	4	1.7	-
Total	233	100.0	-

 Denominator for determinable outcomes = 211 (cases with an ascertainable live-birth or stillbirth status). Eight previable fetal losses originally coded as stillbirth were reclassified as abortion/intrauterine fetal death in line with the study definition (see Methods); the stillbirth rate is therefore 54/211 = 25.6%.

Variation in stillbirth rate

Table 3 presents stillbirth rates across time, geography, cause of maternal death, maternal age, parity, gestational age and antenatal attendance. Annual rates rose and fell without a sustained decline (Fig. 2); the lowest figure, 9.7% in 2022, rested on 31 known outcomes and was not maintained, with rates returning to 25–29% in every subsequent year (Cochran-Armitage test for trend, p = 0.40).

Table 3

Stillbirth rate by year, geography, cause of maternal death, and maternal and obstetric characteristics

Characteristic	Determinable outcomes (n)	Stillbirths (n)	Stillbirth rate (%)
Year of death			
2019	34	11	32.4
2020	17	5	29.4
2021	18	5	27.8
2022	31	3	9.7
2023	33	9	27.3
2024	43	11	25.6
2025	35	10	28.6
Geographic setting			
Island	8	2	25.0
Mainland	203	52	25.6
Cause of maternal death			
Haemorrhage (77 deaths, 33.0%)	71	20	28.2
Sepsis (43 deaths, 18.5%)	40	11	27.5
Cardiovascular (26 deaths, 11.2%)	23	6	26.1
Hypertensive disorders (22 deaths, 9.4%)	21	7	33.3
Malaria (8 deaths, 3.4%)	6	2	33.3
Anaemia (8 deaths, 3.4%)	8	0	0.0
Abortion-related (3 deaths, 1.3%)	2	0	0.0
Other / unknown (46 deaths, 19.7%)	40	8	20.0
Maternal age group, years			

Island versus mainland: live birth chi-square = 0.58, p = 0.45; stillbirth chi-square = 0.01, p = 0.93. Trend across years (Cochran-Armitage): p = 0.40. Antenatal visits, fewer than 4 versus 4 or more: chi-square = 0.01, p = 0.91. ‡ Restricted to the 207 cases with a valid recorded gestational age; the under-28-week group contains no stillbirths by definition following reclassification (see Methods). § Antenatal-care attendance was recorded for 186 of 233 women (80%).

Characteristic	Determinable outcomes (n)	Stillbirths (n)	Stillbirth rate (%)
< 20	25	5	20.0
20–24	47	6	12.8
25–29	49	12	24.5
30–34	36	15	41.7
≥ 35	46	13	28.3
Parity group			
Nulliparous (0)	24	5	20.8
1–2	81	17	21.0
3–4	47	12	25.5
≥ 5	59	20	33.9
Gestational age group			
< 28 weeks	17	0	0.0
28–31 weeks	17	8	47.1
32–36 weeks	81	24	29.6
≥ 37 weeks	74	17	23.0
Antenatal visits			
Fewer than 4	94	23	24.5
4 or more	76	18	23.7
Not recorded	41	13	31.7

Island versus mainland: live birth chi-square = 0.58, p = 0.45; stillbirth chi-square = 0.01, p = 0.93. Trend across years (Cochran-Armitage): p = 0.40. Antenatal visits, fewer than 4 versus 4 or more: chi-square = 0.01, p = 0.91. Restricted to the 207 cases with a valid recorded gestational age; the under-28-week group contains no stillbirths by definition following reclassification (see Methods). Antenatal-care attendance was recorded for 186 of 233 women (80%).

Island and mainland women did not differ significantly in live-birth rate (50.0% versus 68.9%; chi-square = 0.58, p = 0.45) or stillbirth rate (25.0% versus 25.6%; chi-square = 0.01, p = 0.93). The island group numbered only nine women, so the comparison had almost no power. No macerated stillbirths occurred among island cases, and the documented referral rate was lower among them (77.8% versus 87.9%).

Fetal loss varied with the cause of maternal death (Fig. 3). Stillbirth rates were highest where the mother died of a hypertensive disorder or malaria (33.3% each, on 21 and 6 determinable outcomes

respectively), followed by haemorrhage (28.2%), sepsis (27.5%) and cardiovascular causes (26.1%). Haemorrhage was the single commonest cause of maternal death (77 deaths, 33.0% of the cohort) yet carried an intermediate fetal loss. No stillbirths were recorded among the eight anaemia-related deaths, but this rests on too few cases to interpret.

Stillbirth did not increase monotonically with maternal age: it was lowest in the 20–24 group (12.8%) and highest in the 30–34 group (41.7%), with the 35 years and over group lower at 28.3%. Parity followed a more conventional gradient, rising from 20.8% in nulliparous women to 33.9% in grand multiparous women (five or more previous births). With gestational age recovered for 207 cases, the highest stillbirth rate fell in the 28–31 week window (47.1%, 8/17) and declined across the 32–36 week (29.6%) and term (23.0%) groups; by definition the under-28-week group contained no stillbirths after reclassification. Antenatal attendance showed no association with stillbirth: women attending fewer than four visits had almost the same rate as those attending four or more (24.5% versus 23.7%; chi-square = 0.01, p = 0.91).

Early neonatal outcomes

Here the records nearly fall silent. Only six cases in the entire cohort could be linked to perinatal registers with explicit neonatal follow-up; of these, three infants died in the early neonatal period and three survived. To go further we examined free-text fields and outcome columns for the 116 live births with usable narrative. Nine of these 116 (7.8%) contained language indicating an early neonatal death, while 107 (92.2%) were recorded as alive with nothing to the contrary. Extrapolated to all 117 live births, the best available estimate is that approximately nine infants (7.7%) died in the early neonatal period. Because the registers almost never follow the infant past delivery, any early neonatal death occurring after discharge or transfer is invisible in these data and the true rate is very likely higher.

Exploratory linkage to the provincial perinatal-death register

The provincial perinatal-death register recorded 482 perinatal deaths over 2024–2025: 345 stillbirths (169 fresh, 176 macerated) and 137 early neonatal deaths of live-born infants. These records describe, with infant-level detail, exactly the deaths the maternal register loses sight of (Table 4). Fifty-six per cent of the early neonatal deaths occurred within the first 48 hours of life, more than half the infants were of low birth weight (median 2,200 g; 56% below 2,500 g), and the leading causes were birth asphyxia (32%) and prematurity (26%).

Table 4
Characteristics of early neonatal deaths recorded in the provincial perinatal-death register, Luapula Province, 2024–2025 (n = 137)

Characteristic	Category	n	%
Timing of death	First 48 hours	77	56
	Days 3–7	60	44
Birth weight	Low birth weight (< 2,500 g)	71	56
	Very low birth weight (< 1,500 g)	29	23
Leading cause	Birth asphyxia	44	32
	Prematurity	36	26
	Congenital anomaly	23	17
	Sepsis / infection	7	5

 Birth-weight percentages use the 126 records with a recorded weight (median 2,200 g); timing percentages use all 137. The register also recorded 345 stillbirths (169 fresh, 176 macerated) over the same two years. This register is separate from the maternal surveillance system and covers all perinatal deaths in the province, not only those following a maternal death.

Probabilistic linkage was possible only for the 34 maternal deaths in 2025 that recorded maternal initials. Of these, nine (26.5%) were tentatively linked to a perinatal death in the register: six stillbirths and three apparent early neonatal deaths. These links are indicative rather than confirmed, since initials are a weak identifier and false matches cannot be excluded; nonetheless the 26.5% linked-loss rate falls close to the cohort's 25.6% stillbirth rate. Equally telling is what the exercise could not do: two parallel surveillance systems capturing the same events in the same facilities share no common identifier.

Multivariable analysis

Three nested logistic regression models of stillbirth versus live birth are presented in Table 5. In the core model (n = 163, 51 events), no predictor reached significance, but maternal age came closest, with an adjusted odds ratio of 1.08 per year (95% CI 1.00-1.17, p = 0.060), corresponding to an 8% increase in the odds of stillbirth for each additional year (Fig. 4). Parity, referral status and island residence were not associated with the outcome. Adding antenatal-care attendance (Model 2, n = 129) and then gestational age (Model 3, n = 124) did not change the picture materially: fewer than four antenatal visits was not associated with stillbirth (adjusted OR 1.59, 95% CI 0.72–3.51, p = 0.26) and gestational age per week was likewise non-significant (adjusted OR 0.95, 95% CI 0.85–1.06, p = 0.38). Maternal age strengthened to conventional significance in both restricted models (adjusted OR 1.13 and 1.12 per year, p = 0.016 and 0.017), so age is best read as a consistent if modest signal rather than a firmly established predictor. All three models explained little of the variation in outcome (pseudo-R^2 0.031, 0.067 and 0.074 respectively).

Table 5
Nested multivariable logistic regression models for stillbirth versus live birth

Predictor	Model 1 (n = 163)[1]	Model 2 (n = 129)[2]	Model 3 (n = 124)[3]
Maternal age, per year	1.08 (1.00-1.17), p = 0.060	1.13 (1.02–1.24), p = 0.016	1.12 (1.02–1.24), p = 0.017
Parity, per unit	0.93 (0.76–1.14), p = 0.48	0.85 (0.66–1.09), p = 0.20	0.87 (0.68–1.12), p = 0.28
Referred vs direct admission	1.32 (0.48–3.57), p = 0.59	0.89 (0.27–2.95), p = 0.84	1.00 (0.30–3.33), p = 0.99
Island vs mainland	2.14 (0.27–16.65), p = 0.47	3.02 (0.20–45.9), p = 0.43	2.54 (0.16–40.3), p = 0.51
Antenatal visits < 4 vs ≥ 4	-	1.59 (0.72–3.51), p = 0.26	1.55 (0.68–3.53), p = 0.29
Gestational age, per week	-	-	0.95 (0.85–1.06), p = 0.38
Events / n	51 / 163	40 / 129	40 / 124
Pseudo-R^2	0.031	0.067	0.074

Values are adjusted odds ratios (95% confidence interval) and p-values. Outcome: stillbirth (1) versus live birth (0). [1] Core demographic and geographic model. [2] Model 1 plus antenatal-care attendance. [3] Model 2 plus gestational age. Each model uses complete cases for the variables entered, which accounts for the differing denominators. Reference categories: four or more antenatal visits; mainland; direct admission.

Discussion

In this seven-year provincial census of facility-based maternal deaths, one fetus in four died alongside its mother, and the loss was overwhelmingly intrapartum in character. Fresh stillbirths outnumbered macerated stillbirths 3.5:1, and the stillbirth rate showed no downward trend between 2019 and 2025. The cause of the mother's death shaped the fetal prognosis, with hypertensive and malarial deaths carrying the highest fetal loss. Neither antenatal attendance nor gestational age predicted stillbirth, and no factor was robustly significant in adjusted models. Finally, early neonatal follow-up was so incomplete that the burden of neonatal death after maternal loss could not be measured.

A fresh-dominant stillbirth pattern is a marker of the third delay

A stillbirth rate of 25.6% among maternal deaths far exceeds the national background rate and confirms that these women represent an extreme tail of obstetric risk. The fresh-to-macerated ratio is the most informative figure in the analysis. In well-resourced settings fresh stillbirths are comparatively uncommon because fetal distress is detected and acted upon before death; a ratio this high is a

recognised marker of delay in receiving adequate care after reaching a facility - the third of the three delays [25–27] - and matches what has been reported across sub-Saharan Africa, where intrapartum stillbirth predominates [4, 28]. Boerma and colleagues argued that the co-occurrence of maternal death and fresh stillbirth is a sentinel signal of health-system failure [1], and these data support that reading. The flat trend across seven years indicates that emergency obstetric capability for critically ill mothers has not improved in a way that registers in fetal survival.

Why haemorrhage differs

The cause-specific pattern is clinically coherent. Hypertensive and malarial crises compromise uteroplacental perfusion over hours, and may leave the fetus beyond rescue even where the mother is briefly stabilised; the placental pathophysiology of severe pre-eclampsia is well characterised [29]. Much obstetric haemorrhage, by contrast, is postpartum, so the fetus is no longer at risk of intrauterine asphyxia, and even in antepartum bleeding a rapid caesarean can sometimes deliver a live infant. The clinical implication is direct: a mother deteriorating from a hypertensive or cardiovascular cause warrants especially aggressive fetal surveillance and, where the fetus is viable, expedited delivery, because the fetus is in danger well before the mother's collapse becomes irreversible.

Antenatal attendance did not distinguish survivors

The null association between antenatal attendance and stillbirth deserves comment, because antenatal care is rightly emphasised in maternal and newborn programming [30–31]. In this cohort, however, every woman had already died, and among them the number of antenatal visits did not distinguish which fetuses were lost. This is consistent with the quality-coverage gap: contact with the health system is not the same as effective care [14–15], and in maternal-death cases fetal survival appears to be decided in the intrapartum emergency rather than during pregnancy-stage screening. The finding argues for investment in emergency obstetric and newborn capability alongside, not instead of, antenatal coverage [32–33].

Non-significance for island residence is invisibility, not equity

On its face the absence of an island-mainland difference contradicts the island-effect hypothesis, but three considerations caution against that reading. The island group comprised nine women, so the comparison was effectively powerless: an 18-percentage-point difference in live-birth rate did not approach significance. The island cases that did reach a facility were a selected minority who managed the boat journey, the referral chain and the cost, while women who died at home or in transit never entered the MPDSR system at all. Studies capturing community-level events consistently find that remoteness drives perinatal loss, largely through deaths occurring before any facility contact - precisely the events a facility-based study cannot observe [18–19]. The lower documented referral rate among island cases most likely reflects incomplete recording of long, improvised journeys rather than easier access. The honest conclusion is that non-significance here reflects invisibility rather than safety.

The hidden gap: what happens to the surviving newborn

The most troubling result is not a number but its absence. With only six formally linked records and a text-inferred estimate from 116 live births, the 7.7% early neonatal death figure rests on weak foundations, and the true rate among infants whose mothers die is almost certainly higher; the wider literature consistently documents sharply elevated infant mortality after a maternal death, driven by prematurity, asphyxia, sepsis and the loss of maternal feeding and care [8–10]. The exploratory triangulation made this concrete: the provincial perinatal register documented 137 early neonatal deaths over two years, more than half within 48 hours and dominated by birth asphyxia and prematurity [34] - causes highly sensitive to the quality and timeliness of intrapartum and immediate newborn care. That the two registers share no common identifier, so that the infant had to be recovered by probabilistic guesswork, is itself the finding. A surveillance system built to learn from every maternal death stops watching at delivery, at exactly the point where the postnatal continuum of care should begin [11, 35].

What the models could not measure

The regression models explained very little variance (pseudo-R^2 0.03–0.07). This is a measurement problem rather than a statistical one. What plausibly drives fetal survival in maternal-death cases is clinical and temporal - the cause, the speed of recognition, the interval from decision to caesarean, the availability of blood, the quality of neonatal resuscitation - and almost none of it is captured in routine registers. The single borderline signal, maternal age, merits neither dismissal nor over-interpretation, particularly as it is not modifiable. The null result for referral status is itself informative but mainly because referral was near-universal (87.6%), leaving too few direct admissions for a fair comparison; what matters is less whether a woman was referred than what happened during the journey and on arrival. Notably, an apparent protective effect of gestational age seen before data cleaning proved to be an artefact of previable losses misclassified as stillbirths, a reminder of how heavily conclusions in this field depend on data quality.

Limitations

Several limitations bound these conclusions. The island subgroup (n = 9) was far too small to detect real differences, so non-significance must not be read as equity. The study was facility-based and therefore excluded deaths at home, in transit, or on islands without facility contact, and cannot speak to community mortality. Gestational age and antenatal care had to be recovered from source line lists, and although recovery restored completeness to 89% and 80% respectively and validated well against retained records, the 2024–2025 match used a composite key rather than a unique identifier. Early neonatal outcomes were formally linked in fewer than 1% of cases, and the 7.7% estimate leans on text inference of unknown accuracy; it should be regarded as a lower bound. The provincial aggregate summary counted 257 maternal deaths against the 233 line-listed cases analysed here, with the shortfall concentrated in 2023; the missing cases exist only as aggregate counts and could not be recovered, so that year may be under-represented. Cause of death was standardised from free text, so

misclassification is possible, particularly within the sizeable other/unknown group. The linkage to the perinatal register was exploratory, restricted to 2025, and based on a weak identifier. Finally, the retrospective design supports association rather than causation, and the registers lack the process-of-care variables most likely to be the true determinants of survival.

Implications

These findings extend the three-delays model from maternal to perinatal outcomes: the high fresh-stillbirth rate is the third delay made visible in the fetus, while the geographic and referral patterns speak to the first and second [25]. They also expose a conceptual flaw in current surveillance practice, which treats maternal and perinatal death as parallel streams when they are frequently the same system failure observed twice. Three practical steps follow. First, every maternal death review in Zambia should record the fetal and neonatal outcome as a mandatory field, and should follow the surviving infant to at least seven days. Second, the maternal and perinatal surveillance streams should share a mother-infant identifier, which would convert the probabilistic linkage attempted here into a deterministic and auditable one. Third, given that fetal loss in these cases is predominantly intrapartum, investment should prioritise the third delay - decision-to-delivery interval, blood availability, and newborn resuscitation capability at the facilities where critically ill mothers actually arrive [15, 35].

Conclusions

Among 233 facility-based maternal deaths in Luapula Province between 2019 and 2025, one quarter of determinable fetal outcomes were stillbirths, predominantly fresh, and this did not improve across the period. The cause of the mother's death shaped fetal prognosis, but no maternal, obstetric or geographic factor emerged as a robust independent predictor once the data were properly cleaned. The apparent absence of an island disadvantage reflects the invisibility of island women in facility data rather than their safety. Most importantly, early neonatal follow-up within MPDSR is so inadequate that the burden of neonatal death after maternal loss cannot be measured - a gap that is itself a call to action. Recording perinatal outcomes in every maternal death review, and linking the maternal and perinatal surveillance streams through a shared identifier, would make the double tragedy visible and actionable in Zambia and in comparable settings.

Abbreviations

ANC
antenatal care
CI
confidence interval
EmONC
emergency obstetric and newborn care
ENND

early neonatal death
FSB
fresh stillbirth
ICD-MM
International Classification of Diseases - Maternal Mortality
IQR
interquartile range
LAMUBREC
Lusaka Apex Medical University Bio-Medical Research Ethics Committee
MDSR
maternal death surveillance and response
MPDSR
maternal and perinatal death surveillance and response
MSB
macerated stillbirth
NHRA
National Health Research Authority
OR
odds ratio
SD
standard deviation
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
WHO
World Health Organization.

Declarations

Ethics approval and consent to participate

Ethical approval was granted by the Lusaka Apex Medical University Bio-Medical Research Ethics Committee (reference LAMUBREC No. 08019/07/04/2026, 7 April 2026), and authority to conduct the research was granted by the Zambian National Health Research Authority (reference NHRA-3643/26/05/2026, 10 June 2026). Gatekeeper permission was obtained from the Luapula Provincial Health Office and from each participating facility. Both committees granted a waiver of individual informed consent, on the grounds that the study analyses retrospective routine records, the women concerned are deceased, and de-identification at the point of extraction confined risk to the minimal informational level. All methods were carried out in accordance with the Declaration of Helsinki and with Zambia's Data Protection Act.

Consent for publication

Not applicable. No individually identifiable data are presented.

Availability of data and materials

The dataset analysed in this study consists of de-identified records abstracted from the Luapula Provincial Health Office Maternal Death Surveillance and Response system and from facility maternity and neonatal registers. These data are not publicly available because they derive from a national health surveillance system containing sensitive information about deceased women and their infants, and custodianship rests with the Zambian Ministry of Health. The de-identified, analysis-ready dataset and its data dictionary are available from the corresponding author (charleschongokabwebwe@gmail.com) on reasonable request, under a signed data-use agreement and subject to written approval from the Luapula Provincial Health Office and the Zambian National Health Research Authority. All aggregated results supporting the conclusions of this article are included within the article and its additional files.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

CK conceived and designed the study, obtained ethical and regulatory approvals, led data abstraction from the provincial surveillance system and facility registers, performed the statistical analysis, prepared Tables 1-5 and Figures 1-4, and drafted the main manuscript text. KC and SN supervised the study, contributed to the study design and the analysis plan, and critically revised the manuscript for important intellectual content. KK contributed to data collection and abstraction, resolved discrepancies arising during double abstraction, and contributed to interpretation of the findings. All authors reviewed and approved the final manuscript.

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Figures

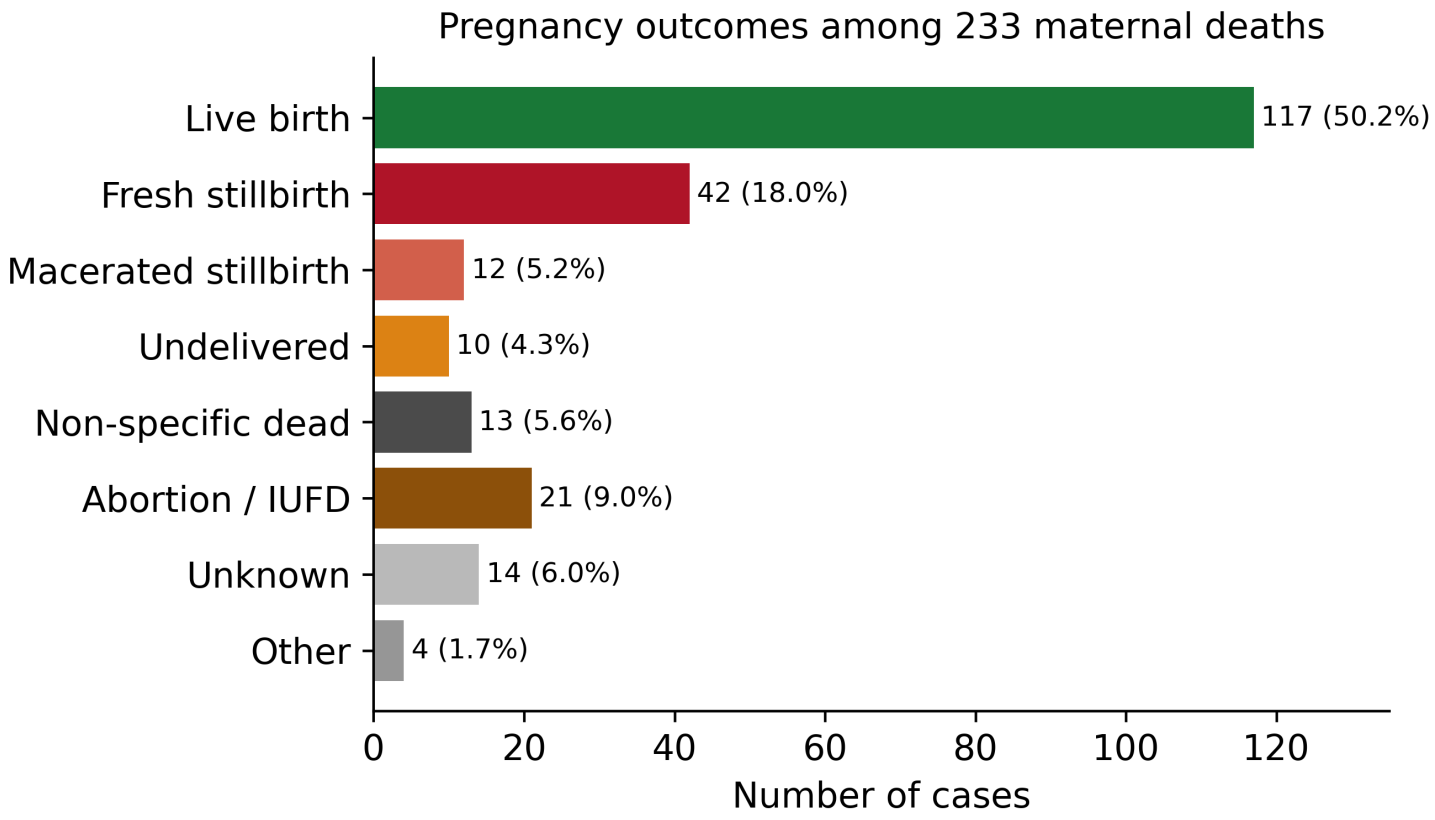


Figure 1

Distribution of pregnancy outcomes among 233 facility-based maternal deaths, Luapula Province, 2019-2025.

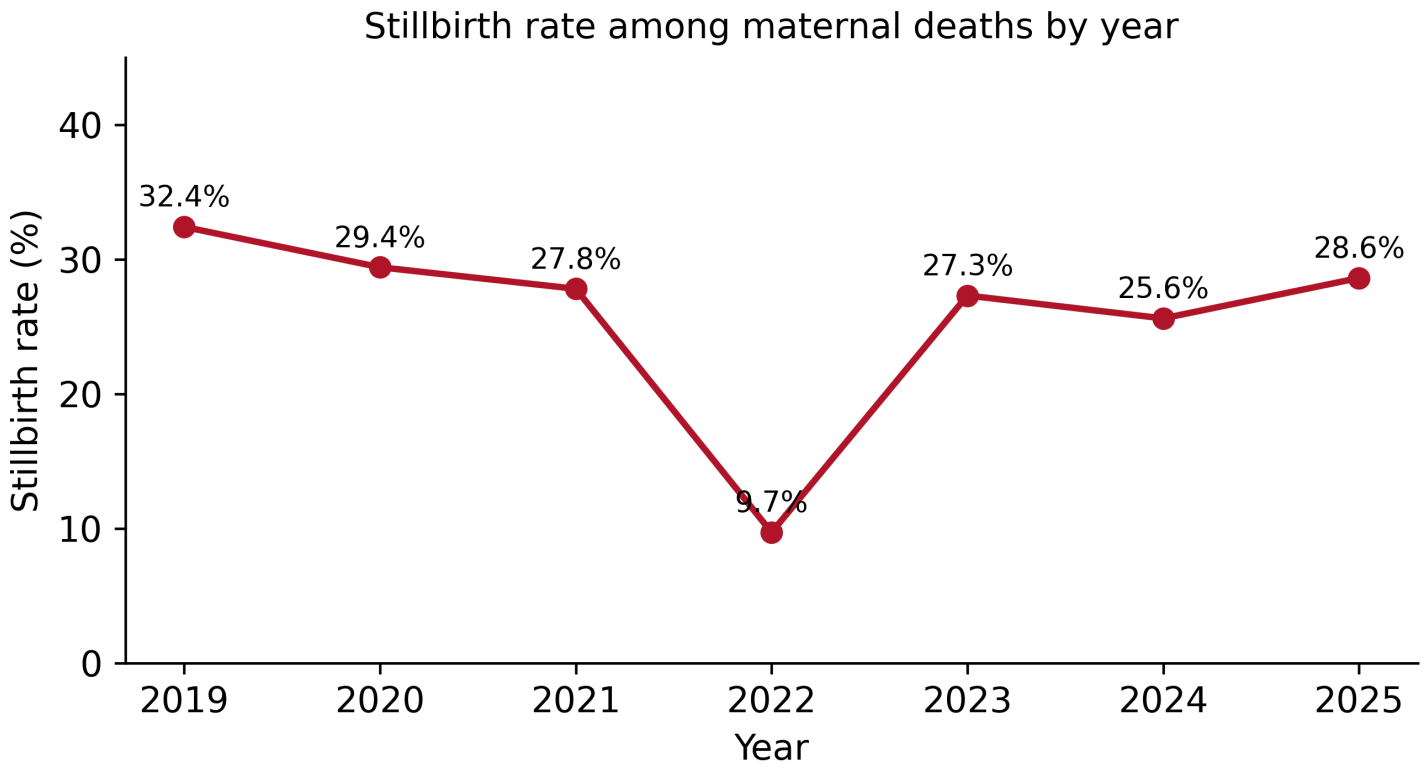


Figure 2

Stillbirth rate among maternal deaths with a determinable fetal outcome, by year of death, 2019-2025. Denominators by year are given in Table 3.

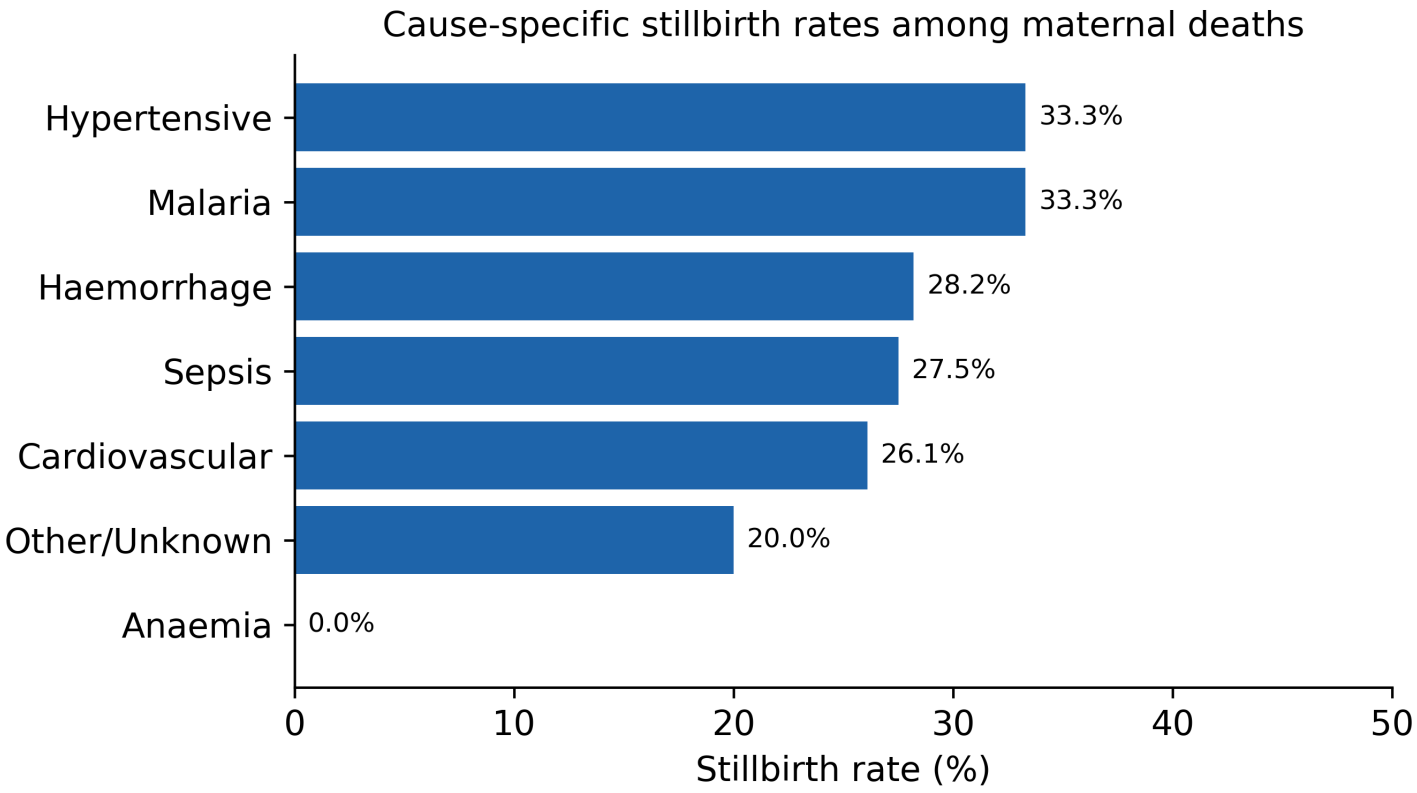


Figure 3

Cause-specific stillbirth rate among maternal deaths, by ICD-MM cause group.

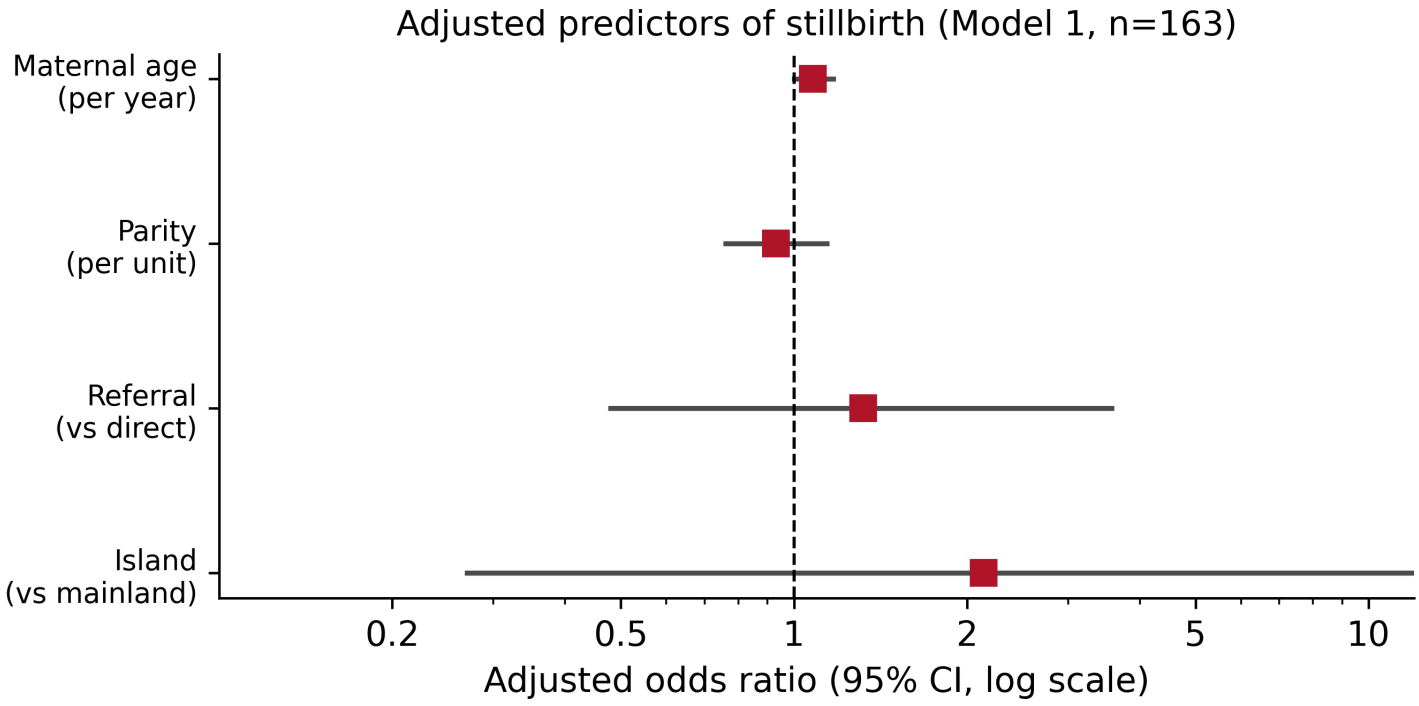


Figure 4

Forest plot of adjusted odds ratios for predictors of stillbirth, core model (Model 1, n = 163). The horizontal axis is on a logarithmic scale; bars show 95% confidence intervals.