ORIGINAL ARTICLE

Characteristics of fetal and neonatal deaths registered in San Martín, Peru, 2011–2025

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ABSTRACT

Objective: To describe the clinical and epidemiological characteristics of fetal and neonatal deaths registered in San Martín, Peru, from 2011 to 2025 and to evaluate the association between neonatal death characteristics and timing of death.
Methods: This observational analytical study was based on publicly available regional data. Clinical, obstetric, geographic, and temporal variables were summarized using frequencies, percentages, medians, and interquartile ranges. Among neonatal deaths with classifiable timing of death, characteristics were compared according to timing of death: less than 24 hours, 1–6 days, and 7–27 days. Adjusted prevalence ratios (aPRs) were estimated using Poisson regression with robust variance.
Results: A total of 3,084 deaths were analyzed: 1,423 (46.1%) fetal and 1,661 (53.9%) neonatal. Among neonatal deaths, 1,130 (68.0%) occurred in preterm newborns and 1,127 (67.9%) in newborns with low birth weight. The most frequent causes of neonatal death were other causes (28.0%), prematurity-immaturity (27.7%), and infections (24.6%). Among the 1,637 neonatal deaths with classifiable timing of death, 572 occurred within the first 24 hours, 715 at 1–6 days, and 350 at 7–27 days. Among neonatal deaths, the proportion occurring within the first 24 hours was higher in records with a gestational age of less than 28 weeks (aPR = 1.88; 95% CI: 1.55–2.28), asphyxia and related causes (aPR = 3.25; 95% CI: 2.58–4.11), congenital malformations or lethal congenital malformation (aPR = 2.74; 95% CI: 2.11–3.56), and prematurity-immaturity (aPR = 1.76; 95% CI: 1.37–2.26).
Conclusions: Neonatal deaths were concentrated among preterm and low-birth-weight newborns. Deaths occurring within the first 24 hours showed a profile characterized by extreme prematurity, asphyxia and related causes, and congenital or lethal malformations. These findings describe differences in the timing of death and do not estimate mortality risk among live-born infants.

Keywords: Fetal Death; Perinatal Death; Infant Mortality (Source: MeSH)

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Características de las muertes fetales y neonatales registradas en San Martín, Perú, 2011–2025

RESUMEN

Objetivo: Describir las características clínico-epidemiológicas de las defunciones fetales y neonatales registradas en San Martín, Perú, durante 2011–2025 y evaluar la asociación entre las características de las defunciones neonatales y el momento del fallecimiento.
Métodos: Estudio observacional y analítico basado en datos públicos regionales. Se resumieron las variables clínicas, obstétricas, geográficas y temporales mediante frecuencias, porcentajes, medianas y rangos intercuartílicos. Entre las defunciones neonatales con momento clasificable, se compararon las características según el momento del fallecimiento: menos de 24 horas, 1–6 días y 7–27 días. Se estimaron razones de prevalencia ajustadas (RPa) mediante regresión de Poisson con varianza robusta.
Resultados: Se analizaron 3 084 defunciones: 1 423 (46,1 %) fetales y 1 661 (53,9 %) neonatales. Entre las defunciones neonatales, 1 130 (68,0 %) ocurrieron en recién nacidos prematuros y 1 127 (67,9 %) en recién nacidos con bajo peso al nacer. Las causas neonatales más frecuentes fueron otras causas (28,0 %), prematuridad-inmadurez (27,7 %) e infecciones (24,6 %). Entre las 1 637 defunciones neonatales con momento de fallecimiento clasificable, 572 ocurrieron en las primeras 24 horas, 715 entre 1 y 6 días y 350 entre 7 y 27 días. Entre las defunciones neonatales, el fallecimiento en las primeras 24 horas fue proporcionalmente más frecuente en los registros con una edad gestacional menor de 28 semanas (RPa = 1,88; IC 95 %: 1,55–2,28), asfixia y causas relacionadas (RPa = 3,25; IC 95 %: 2,58–4,11), malformaciones

congénitas o malformación congénita letal (RPa = 2,74; IC 95 %: 2,11–3,56) y prematuridad-inmadurez (RPa = 1,76; IC 95 %: 1,37–2,26).

Conclusiones: Las defunciones neonatales se concentraron en recién nacidos prematuros y con bajo peso. Las defunciones ocurridas en las primeras 24 horas presentaron un perfil caracterizado por prematuridad extrema, asfixia y causas relacionadas, así como por malformaciones congénitas o letales. Estos hallazgos describen diferencias en el momento de la defunción y no estiman el riesgo de mortalidad entre los nacidos vivos.

Palabras clave: Muerte Fetal; Muerte Perinatal; Mortalidad Infantil (Fuente: DeCS)

INTRODUCTION

Fetal and neonatal mortality is a major global public health challenge and a sensitive indicator of the quality of care during pregnancy, childbirth, and the neonatal period (1,2). In 2022, 2.3 million newborns died within the first 28 days of life (3), accounting for 47% of all deaths among children younger than 5 years. Although neonatal mortality has declined by 44% since 2000, the burden remains greatest in low- and middle-income countries (3,4), where barriers to timely access to health services increase the risk of neonatal death (5).

The World Health Organization (WHO) (6,7) defines fetal death as one that occurs before the complete expulsion or extraction of the product of conception, regardless of the duration of pregnancy, and neonatal death as death occurring during the first 28 days of life (6). Prematurity, intrapartum complications, neonatal infections, and congenital anomalies remain among the leading causes of neonatal death (8). These conditions often coexist with social determinants that restrict access to prenatal care, high-quality obstetric care, and specialized neonatal care (9).

In Peru, neonatal mortality has shown a steady decline; however, substantial disparities persist among departments and are associated with poverty, education, and access to health services (4,10), especially in Amazonian regions, where geographic conditions and population dispersion may influence the pattern of these deaths (11,12).

Characterizing the clinical and epidemiological features of fetal and neonatal deaths can help identify vulnerable populations, recognize patterns of occurrence, and guide prevention strategies tailored to the local context. However, regional evidence based on long-term population registries remains limited in Peru, even though geographic and social differences and disparities in access to health services may affect the profile of these deaths, particularly in Amazonian regions such as San Martín. The first day of life is a clinically distinct period related to neonatal transition, intrapartum care, and initial stabilization (13).

Therefore, this study aimed to describe the clinical and epidemiological characteristics of fetal and neonatal deaths registered in San Martín, Peru, from 2011 to 2025 and to evaluate the association between neonatal death characteristics and timing of death.

METHODS

Study design

An observational, retrospective, and analytical study was conducted, with a descriptive component and a comparative component limited to comparisons of neonatal deaths by timing of death. The study was based on the secondary analysis of a publicly accessible administrative database of fetal and neonatal deaths registered in the San Martín region, which is located in the northeastern Peruvian Amazon and comprises 10 provinces.

Data source

The data source was the "Mortalidad Neonatal y Perinatal" dataset, developed by the Gobierno Regional de San Martín using information from the Dirección Regional de Salud. The database includes records of fetal and neonatal deaths reported in health facilities in the region, as well as variables related to the facility, geographic location, newborn characteristics, diagnosis, type of death, place and setting of delivery (institutional or home), gestational age, birth weight, place of death, and preventability classification. As a surveillance registry, the database allows analysis of reported deaths but does not permit independent verification of completeness, reporting coverage, or the extent of potential underreporting.

Population

The study population comprised all fetal and neonatal deaths registered in San Martín between 2011 and 2025. For the comparative component, fetal and neonatal records with dates, times, or temporal classifications that were inconsistent or could not be used to determine the timing of neonatal death were excluded.

Variables

For the comparative component restricted to neonatal deaths, the outcome was death occurring within the first 24 hours of life versus death occurring between 1 and 27 days; this outcome was defined by the difference between the date and time of birth and the date and time of death. For the descriptive analysis, timing of neonatal death was categorized into three groups: less than 24 hours, 1–6 days, and 7–27 days. The variables included sex, categorized gestational age, categorized birth weight, grouped cause of death, registration period, place of delivery, place of death, province, and preventability classification. Prematurity and low birth weight were retained solely as descriptive clinical summaries and were not entered into the multivariable model simultaneously with the variables from which they were derived. Gestational age was classified as ≥ 37 weeks, 32–36 weeks, 28–31 weeks, and < 28 weeks. Birth weight was categorized as ≥ 2,500 g, 1,500–2,499 g, 1,000–1,499 g, and < 1,000 g. The periods 2011–2015, 2016–2020, and 2021–2025 were defined *a priori* as three consecutive five-year periods of equal duration to facilitate temporal comparisons of the composition of the records. The preventability variable reflected the binary classification recorded in the source and was neither recalculated nor validated by the investigators. Causes of death were grouped by the research team based on the recorded diagnosis and the code from the International

Classification of Diseases, Tenth Revision (ICD-10). Because fetal and neonatal death taxonomies are not equivalent, the categories were interpreted specifically for each type of death; individual low-frequency diagnoses were combined into clinically related groups.

Statistical analysis

Categorical variables were summarized using absolute frequencies and percentages. Numerical variables were described using the median and interquartile range (IQR) because of their non-normal distributions. The initial descriptive analysis compared the characteristics of registered fetal and neonatal deaths. Subsequently, among neonatal deaths, characteristics were compared by timing of death: < 24 hours, 1–6 days, and 7–27 days. The chi-square test or Fisher's exact test was used for bivariate comparisons, as appropriate, and nonparametric tests were used for continuous variables.

To evaluate the association between the characteristics of neonatal deaths and timing of death, Poisson regression models with a log link and robust variance were fitted. The outcome compared deaths occurring within the first 24 hours with those occurring between 1 and 27 days. Crude prevalence ratios (cPRs) and adjusted prevalence ratios (aPRs) were estimated with their corresponding 95% confidence intervals (CIs). The assumptions of the crude model were assessed beforehand. The primary adjusted model included variables selected based on clinical and epidemiological relevance: sex, categorized gestational age, grouped cause of death, registration period, and place of delivery. Multicollinearity was subsequently assessed using the variance inflation factor (VIF), with a cutoff of 5. Data processing, cleaning, and statistical analysis were performed in RStudio (RStudio, PBC, Boston, MA, USA). A p-value < 0.05 was considered statistically significant. Prevalence ratios were interpreted as measures of association with timing of death within the set of neonatal deaths and not as estimates of mortality risk among live-born infants.

Ethical considerations

Because the study used a publicly available, anonymized database without direct personal identifiers, it involved neither contact with participants nor intervention involving human subjects. Accordingly, approval by an ethics committee was not required. The information is publicly available through Peru's Open Data portal.

RESULTS

A total of 3,084 fetal and neonatal deaths registered in the San Martín region from 2011 to 2025 were analyzed (Figure 1). Of these, 1,423 (46.1%) were fetal deaths and 1,661 (53.9%) were neonatal deaths. By study period, 1,225 deaths were registered in 2011–2015 (39.7%), 953 in 2016–2020 (30.9%), and 906 in 2021–2025 (29.4%). The distribution across periods did not differ between fetal and neonatal deaths (p = 0.913). Male sex was recorded in 1,697 cases (55.0%), including 955 neonatal deaths (57.5%). The median gestational age was 34.0 weeks (IQR: 29.0–38.0) overall, 35.0 weeks (IQR: 29.0–39.0) among fetal deaths, and 33.0 weeks (IQR: 29.0–38.0) among neonatal deaths. A gestational age of less than 37 weeks was recorded in 1,952 deaths (63.3%), and low birth weight in 1,989 (64.5%). Among neonatal deaths, 1,130 (68.0%) occurred among preterm newborns and 1,127 (67.9%) among newborns with low birth weight. Most deliveries were institutional (n = 2,811; 91.1%), and most deaths occurred in health facilities (n = 2,649; 85.9%). Among neonatal deaths, delivery was institutional in 1,557 cases (93.7%), and death occurred in a health facility in 1,591 cases (95.8%) (Table 1).

Grouped causes differed by type of registered death. Among fetal deaths, the most frequent categories were fetal death of unspecified cause (n = 687; 48.3%) and intrauterine hypoxia (n = 322; 22.6%). Congenital malformations or lethal congenital malformation were also recorded in 130 cases (9.1%), and other causes in 124 (8.7%). Among neonatal deaths, the most frequently recorded categories were other causes (n = 465; 28.0%), prematurity-immaturity (n = 460; 27.7%), infections (n = 409; 24.6%), asphyxia and related causes (n = 174; 10.5%), and congenital malformations or lethal congenital malformation (n = 151; 9.1%) (Table 2).

Of the 1,661 neonatal deaths, 1,637 had a classifiable timing of death: 572 occurred within the first 24 hours of life, 715 at 1–6 days, and 350 at 7–27 days. The remaining 24 records were not included in this analysis because their timing of death could not be classified. Among deaths occurring within the first 24 hours, 325 were male (56.8%), and 245 were female (42.8%). By gestational age, this group included 173 deaths among neonates at ≥37 weeks (30.2%), 137 at 32–36 weeks (24.0%), 110 at 28–31 weeks (19.2%), and 152 at <28 weeks (26.6%). By birth weight, 158 deaths occurring within the first 24 hours were among neonates weighing <1,000 g (27.6%). The distributions of categorized gestational age and birth weight differed by timing of death (p < 0.001 for both variables). In contrast, the distributions of sex, prematurity, low birth weight, and preventability did not differ significantly across the three timing-of-death categories. Regarding grouped causes according to the timing of neonatal death, among deaths occurring within the first 24 hours, prematurity-immaturity accounted for 177 cases (30.9%), other causes for 146 (25.5%), asphyxia and related causes for 105 (18.4%), infections for 74 (12.9%), and congenital malformations or lethal congenital malformation for 69 (12.1%). Among deaths at 1–6 days, other causes accounted for 214 cases (29.9%), prematurity-immaturity for 195 (27.3%), and infections for 194 (27.1%). Among deaths at 7–27 days, infections accounted for 134 cases (38.3%), other causes for 96 (27.4%), and prematurity-immaturity for 84 (24.0%). The distributions of grouped causes, place of delivery, place of death, and registration period differed by timing of neonatal death (Table 3).

In the adjusted Poisson regression model with robust variance, which was restricted to neonatal deaths and compared deaths occurring within the first 24 hours with those occurring between 1 and 27 days, gestational age <28 weeks had an aPR of 1.88 (95% CI: 1.55–2.28; p < 0.001), with ≥37 weeks as the reference category. Compared with infections, the aPRs were 1.76 for prematurity-immaturity (95% CI: 1.37–2.26; p < 0.001), 3.25 for asphyxia and related causes (95% CI: 2.58–4.11; p < 0.001), 2.74 for congenital malformations or lethal congenital malformation (95% CI: 2.11–3.56; p < 0.001), and 1.64 for other causes (95% CI: 1.28–2.10; p < 0.001).

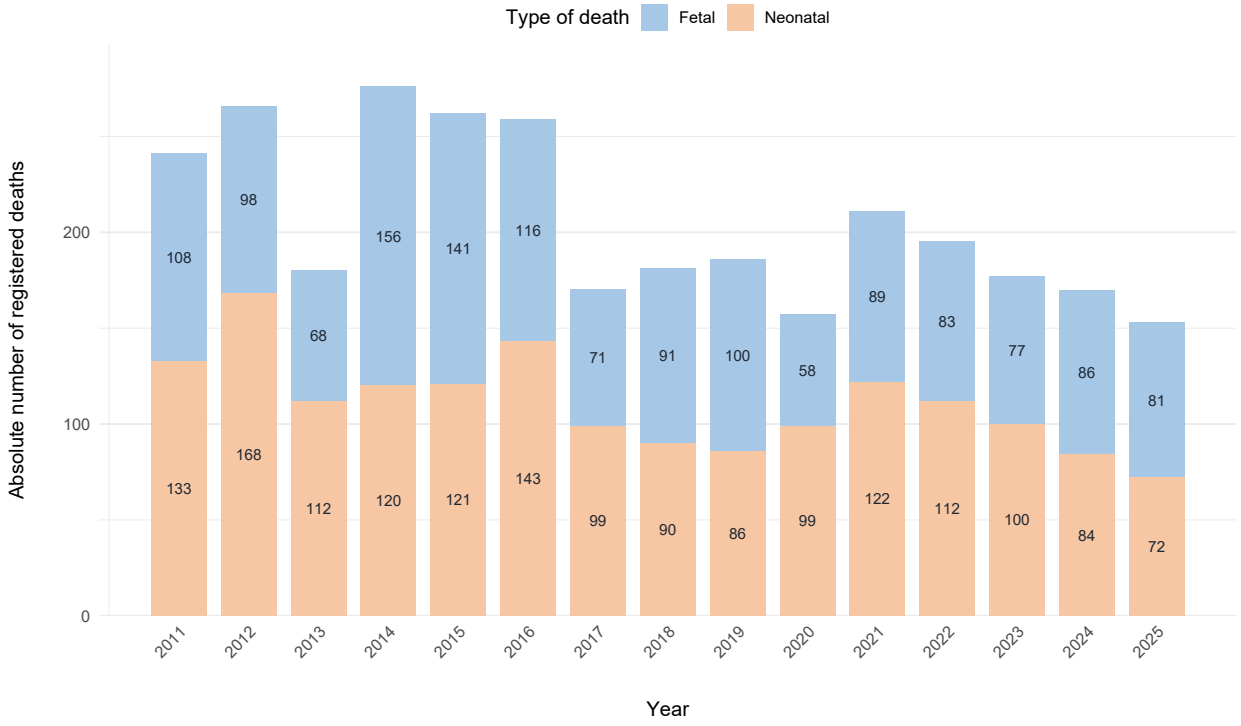

Figure 1. Annual number of fetal and neonatal deaths registered in San Martín, 2011–2025

Values are absolute counts of notifications, not mortality rates.

For 2016–2020 and 2021–2025, the aPRs were 0.76 (95% CI: 0.65–0.89; p < 0.001) and 0.70 (95% CI: 0.59–0.82; p < 0.001), respectively, with 2011–2015 as the reference period. Sex and place of delivery were not statistically significantly associated with timing of death in the adjusted model (Table 4). These estimates describe the relative prevalence of death within the first 24 hours among neonates who died.

DISCUSSION

The pattern of fetal and neonatal deaths registered in the San Martín region from 2011 to 2025 demonstrated high perinatal vulnerability. This vulnerability was reflected in the high frequencies of prematurity (68.0%) and low birth weight (67.9%), as well as in the concentration of neonatal deaths within the first 24 hours of life. Among neonatal deaths, one of the most relevant findings was the higher relative frequency of death on the first day in records of neonates with a gestational age of <28 weeks and in deaths attributed to prematurity-immaturity or asphyxia.

The leading causes of neonatal death identified in this study are consistent with patterns reported nationally. Prematurity-immaturity, infections, asphyxia and related causes, and lethal congenital malformations have been reported as important categories of neonatal mortality in Peru (12,14). Accordingly, these causes accounted for a substantial proportion of the neonatal deaths registered in this study. However, "other causes" was the most frequent category, accounting for 465 cases (28.0%), which limits specific etiologic interpretation and may reflect diagnostic heterogeneity, variability in classification, or clinical imprecision in administrative records (15).

Analysis of the timing of death helps identify periods of greater neonatal vulnerability. Among neonatal deaths with classifiable timing, 572 occurred within the first 24 hours of life and 715 at 1–6 days, indicating that the greatest burden was concentrated in the early neonatal period. This pattern is consistent with previous studies reporting that neonatal mortality and severe morbidity tend to cluster in the first postnatal days, particularly on the first day of life (15). These findings highlight the importance of intrapartum and immediate neonatal care, including obstetric monitoring, neonatal resuscitation, initial stabilization, and timely referral of critically ill newborns. The proportions of deaths classified as preventable were similar across the three timing-of-death categories; because this classification was derived from the registry and was not reassessed by the authors, the absence of differences should be interpreted with caution.

Among the neonatal deaths analyzed, extreme prematurity was associated with a higher proportion of deaths occurring within the first 24 hours. Although prematurity, when evaluated as a dichotomous variable, did not differ significantly by timing of death, the analysis by gestational age categories showed that the relative proportion of deaths on the first day was higher among neonates with a gestational age of <28 weeks. Additionally, the adjusted prevalence of death on the first day was 88.0% higher among neonates with a gestational

Table 1. General characteristics of fetal and neonatal deaths registered in San Martín, 2011–2025

Characteristic	Total n = 3,084 n (%)	Fetal n = 1,423 n (%)	Neonatal n = 1,661 n (%)	p
Period				0.913
2011–2015	1,225 (39.7)	571 (40.1)	654 (39.4)	
2016–2020	953 (30.9)	436 (30.6)	517 (31.1)	
2021–2025	906 (29.4)	416 (29.2)	490 (29.5)	
Sex				< 0.001
Female	1,350 (43.8)	647 (45.5)	703 (42.3)	
Male	1,697 (55.0)	742 (52.1)	955 (57.5)	
Indeterminate/other	37 (1.2)	34 (2.4)	3 (0.2)	
Gestational age, weeks median (IQR)	34.0 (29.0–38.0)	35.0 (29.0–39.0)	33.0 (29.0–38.0)	< 0.001
Categorized gestational age				< 0.001
≥ 37 weeks	1,132 (36.7)	601 (42.2)	531 (32.0)	
32–36 weeks	808 (26.2)	341 (24.0)	467 (28.1)	
28–31 weeks	574 (18.6)	206 (14.5)	368 (22.2)	
< 28 weeks	570 (18.5)	275 (19.3)	295 (17.8)	
Gestational age < 37 weeks				< 0.001
No	1,132 (36.7)	601 (42.2)	531 (32.0)	
Yes	1,952 (63.3)	822 (57.8)	1,130 (68.0)	
Birth weight, g median (IQR)	1,927.5 (1,100.0–2,910.0)	2,070.0 (1,100.0–3,010.0)	1,800.0 (1,080.0–2,800.0)	0.002
Categorized birth weight				< 0.001
≥ 2,500 g	1,095 (35.5)	561 (39.4)	534 (32.1)	
1,500–2,499 g	800 (25.9)	351 (24.7)	449 (27.0)	
1,000–1,499 g	551 (17.9)	215 (15.1)	336 (20.2)	
< 1,000 g	638 (20.7)	296 (20.8)	342 (20.6)	
Low birth weight				< 0.001
No	1,095 (35.5)	561 (39.4)	534 (32.1)	
Yes	1,989 (64.5)	862 (60.6)	1,127 (67.9)	
Province				< 0.001
Bellavista	234 (7.6)	113 (7.9)	121 (7.3)	
El Dorado	170 (5.5)	78 (5.5)	92 (5.5)	
Huallaga	78 (2.5)	31 (2.2)	47 (2.8)	
Lamas	320 (10.4)	153 (10.8)	167 (10.1)	
Mariscal Cáceres	185 (6.0)	56 (3.9)	129 (7.8)	
Moyobamba	559 (18.1)	247 (17.4)	312 (18.8)	
Picota	158 (5.1)	72 (5.1)	86 (5.2)	
Rioja	470 (15.2)	245 (17.2)	225 (13.5)	
San Martín	702 (22.8)	306 (21.5)	396 (23.8)	
Tocache	208 (6.7)	122 (8.6)	86 (5.2)	
Place of delivery[a]				< 0.001
Home	272 (8.8)	168 (11.8)	104 (6.3)	
Institutional	2,811 (91.1)	1,254 (88.1)	1,557 (93.7)	
Not recorded	1 (< 0.1)	1 (0.1)	0 (0.0)	
Place of death				< 0.001
Community/home	435 (14.1)	365 (25.7)	70 (4.2)	
Health facility	2,649 (85.9)	1,058 (74.3)	1,591 (95.8)	

IQR: interquartile range. Values are presented as n (%) except for gestational age and birth weight, which are presented as median (IQR). "Indeterminate/other" corresponds to the category recorded in the data source; the database did not allow a missing entry, a coding error, or a specific clinical condition to be distinguished. The dichotomous gestational age variable is retained as a complementary descriptive summary. [a]One place-of-delivery value was missing in the fetal death group. The p-value was calculated using records with available information (n = 3,083).

Table 2. Grouped causes by type of registered death in San Martín, 2011–20255

Grouped cause	Total n (%)	Fetal n (%)	Neonatal n (%)
Fetal death of unspecified cause	687 (22.3)	687 (48.3)	—
Intrauterine hypoxia	322 (10.4)	322 (22.6)	—
Placental, cord, and membrane complications	61 (2.0)	61 (4.3)	—
Maternal complications of pregnancy	31 (1.0)	31 (2.2)	—
Maternal conditions unrelated to the current pregnancy	31 (1.0)	31 (2.2)	—
Short gestation/low birth weight	37 (1.2)	37 (2.6)	—
Prematurity-immaturity	460 (14.9)	—	460 (27.7)
Infections	409 (13.3)	—	409 (24.6)
Asphyxia and related causes	174 (5.6)	—	174 (10.5)
Congenital malformations or lethal congenital malformation	281 (9.1)	130 (9.1)	151 (9.1)
Other causes	589 (19.1)	124 (8.7)	465 (28.0)
Not recorded	2 (0.1)	0 (0.0)	2 (0.1)

Values are presented as n (%). The em dash (—) indicates a category that is not applicable; the fetal and neonatal categories do not constitute a single taxonomy.

Table 3. Characteristics of neonatal deaths by timing of death in the San Martín region, 2011–2025

Characteristic	<24 hours n = 572 n (%)	1–6 days n = 715 n (%)	7–27 days n = 350 n (%)	p
Sex				0.408*
Female	245 (42.8)	294 (41.1)	155 (44.3)	
Male	325 (56.8)	421 (58.9)	194 (55.4)	
Indeterminate/other	2 (0.3)	0 (0.0)	1 (0.3)	
Gestational age				< 0.001
≥ 37 weeks	173 (30.2)	227 (31.7)	122 (34.9)	
32–36 weeks	137 (24.0)	212 (29.7)	114 (32.6)	
28–31 weeks	110 (19.2)	161 (22.5)	91 (26.0)	
< 28 weeks	152 (26.6)	115 (16.1)	23 (6.6)	
Prematurity				0.342
No	173 (30.2)	227 (31.7)	122 (34.9)	
Yes	399 (69.8)	488 (68.3)	228 (65.1)	
Birth weight				< 0.001
≥ 2,500 g	180 (31.5)	235 (32.9)	108 (30.9)	
1,500–2,499 g	138 (24.1)	198 (27.7)	108 (30.9)	
1,000–1,499 g	96 (16.8)	145 (20.3)	91 (26.0)	
< 1,000 g	158 (27.6)	137 (19.2)	43 (12.3)	
Low birth weight				0.770
No	180 (31.5)	235 (32.9)	108 (30.9)	
Yes	392 (68.5)	480 (67.1)	242 (69.1)	
Preventable				0.740
No	444 (77.6)	542 (75.8)	270 (77.1)	
Yes	128 (22.4)	173 (24.2)	80 (22.9)	
Place of delivery				0.006
Home	44 (7.7)	29 (4.1)	28 (8.0)	
Institutional	528 (92.3)	686 (95.9)	322 (92.0)	
Place of death				< 0.001
Community/home	44 (7.7)	10 (1.4)	14 (4.0)	
Health facility	528 (92.3)	705 (98.6)	336 (96.0)	
Period				< 0.001
2011–2015	268 (46.9)	268 (37.5)	113 (32.3)	
2016–2020	160 (28.0)	240 (33.6)	111 (31.7)	
2021–2025	144 (25.2)	207 (29.0)	126 (36.0)	

*Fisher's exact test was used for sex; Pearson's chi-squared test was used for all other comparisons. Values are presented as n (%). Preventability corresponds to the classification recorded in the data source and was not reassessed by the authors. The matching marginal frequencies for place of delivery and place of death in the <24-hour group do not imply individual-level concordance between the two records.

Table 4. Characteristics associated with the occurrence of death within the first 24 hours among neonatal deaths registered in the San Martín region, 2011–2025

Characteristic	cPR	95% CI	p	aPR	95% CI	p
Sex						
Female	—	—	—	—	—	—
Male	0.98	0.86–1.12	0.8	0.96	0.85–1.09	0.6
Gestational age						
≥ 37 weeks	—	—	—	—	—	—
32–36 weeks	0.89	0.74–1.08	0.2	1.01	0.84–1.21	> 0.9
28–31 weeks	0.92	0.75–1.12	0.4	1.09	0.88–1.34	0.4
< 28 weeks	1.58	1.34–1.86	< 0.001	1.88	1.55–2.28	< 0.001
Grouped cause						
Infections	—	—	—	—	—	—
Prematurity-immaturity	2.11	1.67–2.67	< 0.001	1.76	1.37–2.26	< 0.001
Asphyxia and related causes	3.30	2.60–4.18	< 0.001	3.25	2.58–4.11	< 0.001
Congenital malformations or lethal congenital malformation	2.53	1.94–3.31	< 0.001	2.74	2.11–3.56	< 0.001
Other causes	1.74	1.36–2.22	< 0.001	1.64	1.28–2.10	< 0.001
Not recorded	2.72	0.67–11.00	0.2	2.40	0.55–10.50	0.2
Period						
2011–2015	—	—	—	—	—	—
2016–2020	0.76	0.65–0.89	< 0.001	0.76	0.65–0.89	< 0.001
2021–2025	0.73	0.62–0.86	< 0.001	0.70	0.59–0.82	< 0.001
Place of delivery						
Institutional	—	—	—	—	—	—
Home	1.27	1.00–1.60	0.046	1.18	0.94–1.47	0.2

cPR: crude prevalence ratio; aPR: adjusted prevalence ratio; 95% CI: 95% confidence interval. Prevalence ratios were estimated using Poisson regression models with robust variance. The outcome compared deaths occurring within the first 24 hours with those occurring between 1 and 27 days. The adjusted model included sex, categorized gestational age, grouped cause of death, registration period, and place of delivery. The prevalence ratios represent associations conditional on the occurrence of a neonatal death and do not estimate mortality risk among live-born infants.

age of <28 weeks than among those with a gestational age of ≥37 weeks. This finding suggests that extreme prematurity, rather than prematurity in general, is associated with greater immediate vulnerability. Clinically, this is plausible because pulmonary, hemodynamic, metabolic, and neurologic immaturity limits cardiopulmonary transition at birth and reduces the likelihood of stabilization during the first hours of life (16). Moreover, studies have shown that survival among extremely preterm newborns varies markedly by gestational age: it is lower at earlier gestational ages and increases as gestation advances (17,18). The findings from San Martín highlight the need to strengthen the prevention of extremely preterm birth, antenatal referral, and the capacity to provide immediate neonatal care.

In addition to gestational age, the recorded cause of death revealed relevant temporal patterns. In the adjusted model, deaths attributed to asphyxia and related causes had the highest relative prevalence of occurring within the first 24 hours, followed by deaths attributed to congenital malformations or lethal congenital malformation and to prematurity-immaturity. This finding is consistent with population-based studies using vital records (19), such as the study conducted in São Paulo, Brazil, where neonatal mortality associated with perinatal asphyxia was concentrated early, with a median time of approximately 24 hours until 50% of deaths had occurred (20). In the department of San Martín, this pattern highlights the importance of the intrapartum period and the immediate stabilization of the newborn, although the available data do not permit causal inference or direct assessment of the quality of care. In contrast, infections were proportionally more frequent among deaths occurring at 7–27 days, suggesting a later temporal pattern, possibly related to the immunologic vulnerability of preterm infants and to postnatal exposures associated with neonatal care, as described in studies of late-onset neonatal sepsis (21).

Among fetal deaths, the high proportion of cases registered as fetal death of unspecified cause was a noteworthy finding. This category accounted for 48.3% of fetal deaths, far exceeding the proportions attributed to intrauterine hypoxia and to congenital malformations or lethal congenital malformation. This concentration of nonspecific diagnoses limits etiologic interpretation and reduces the registry's usefulness in guiding

preventive interventions. The standardized classification of perinatal deaths, such as the World Health Organization's International Classification of Diseases for Perinatal Mortality (ICD-PM), seeks to link fetal and neonatal deaths to contributing maternal and perinatal conditions, thereby facilitating comparisons across settings and the identification of opportunities for prevention (22). Therefore, the findings suggest a need to improve the quality of records, strengthen the clinical investigation of fetal deaths, and standardize etiologic classification.

In Peru, the study findings should be interpreted in light of the fact that neonatal mortality is not evenly distributed across the country. National studies have shown persistent department-level inequalities associated with poverty and education, indicating that neonatal survival is influenced not only by clinical conditions but also by social and territorial determinants (10). Ecological analyses have also documented a decrease in the neonatal mortality rate in Peru between 2007 and 2021, although regional inequalities persisted and the epidemiologic profile shifted toward a higher proportion of deaths related to extreme prematurity and low birth weight (12). Against this background, among neonatal deaths registered in San Martín, the lower relative prevalence of death within the first 24 hours in 2016–2020 and 2021–2025 than in 2011–2015 could reflect changes in perinatal care, obstetric-neonatal referral, or the initial survival of critically ill newborns; however, it could also have been influenced by changes in the registration or classification of deaths (23,24). This comparison does not constitute an estimate of the trend in the neonatal mortality rate because the study did not include live births as the denominator.

The main strengths of this study include the analysis of 15 years of data and the use of a regional database of fetal and neonatal deaths, which enabled the characterization of clinical and epidemiological patterns and the comparison of characteristics associated with the timing of neonatal deaths. However, the findings should be interpreted in light of the limitations of administrative records, including incomplete data, diagnostic variability, possible underreporting, unverifiable reporting coverage, and the absence of relevant clinical variables. The data source also did not allow antepartum and intrapartum fetal deaths to be distinguished in a standardized manner or the preventability classification to be reassessed. Furthermore, the high frequency of nonspecific categories and the observational design limit etiologic interpretation and preclude causal inference. Nevertheless, these findings provide useful regional evidence to guide interventions focused on preventing extremely preterm birth, improving intrapartum care, stabilizing critically ill newborns, and strengthening perinatal registration.

In conclusion, neonatal deaths registered in San Martín, Peru, from 2011 to 2025 were concentrated among preterm and low-birth-weight newborns. Among neonatal deaths, those occurring within the first 24 hours showed a profile characterized by extreme prematurity, asphyxia and related causes, and congenital malformations or lethal congenital malformation. These findings describe differences in the timing of death among neonates who died and do not estimate mortality risk among live-born infants.

Author contributions

Victor Roman-Lazarte: conceptualization, investigation, methodology, formal analysis, validation, visualization, resources, supervision, project administration, and writing – review and editing. Luz Angela Roman: investigation, resources, data curation, and writing – review and editing. Denisse Lopez-Damian: investigation, data curation, and writing – review and editing. All authors approved the final version of the manuscript.

Conflicts of interest

The authors have no relevant financial or non-financial interests to declare.

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Data availability

The database used in this study was the publicly available dataset "Mortalidad Neonatal y Perinatal", compiled by the Gobierno Regional de San Martín using information from the Dirección Regional de Salud and available on the Datos Abiertos Perú platform. The analysis files and derived results are available from the corresponding author upon request.

REFERENCES

1. Gonzalez RM, Gilleskie D. Infant mortality rate as a measure of a country's health: a robust method to improve reliability and comparability. Demography. 2017;54(2):701-20. doi: 10.1007/s13524-017-0553-7
2. Hessami K, Homayoon N, Hashemi A, Vafaei H, Kasraeian M, Asadi N. COVID-19 and maternal, fetal and neonatal mortality: a systematic review. J Matern Fetal Neonatal Med. 2022;35(15):2936-41. doi: 10.1080/14767058.2020.1806817
3. Sharrow D, Hug L, Liu Y, Fell GW, You D. Global, regional, and national levels and trends in under 5, infant, and neonatal mortality during 1990-2024 with scenario based projections to 2030: modelling study. BMJ. 2026;393:e088684. doi: 10.1136/bmj-2025-088684
4. Ávila Vargas-Machuca JG. Desigualdad en la mortalidad neonatal del Perú generada por la pobreza y educación, 2011-2019. Rev Peru Med Exp Salud Publica. 2022;39(2):178-84. doi: 10.17843/rpmesp.2022.392.10629
5. Lucas R, Thames T, Chestnut JF, DeMaria AL, Stoneburner A. Maternity care access and infant mortality. JAMA Netw Open. 2025;8(11):e2542831. doi: 10.1001/jamanetworkopen.2025.42831
6. Pathirana J, Muñoz FM, Abbing-Karahagopian V, Bhat N, Harris T, Kapoor A, et al. Neonatal death: case definition & guidelines for data collection, analysis, and presentation of immunization safety data. Vaccine. 2016;34(49):6027-37. doi: 10.1016/j.vaccine.2016.03.040
7. Tamir TT. Neonatal mortality rate and determinants among births of mothers at extreme ages of reproductive life in low and middle income countries. Sci Rep. 2024;14(1):12596. doi: 10.1038/s41598-024-61867-w
8. Erchick DJ, Lackner JB, Mullany LC, Bhandari NN, Shedain PR, Khanal S, et al. Causes and age of neonatal death and associations with maternal and newborn care characteristics in Nepal: a verbal autopsy study. Arch Public Health. 2022;80(1):26. doi: 10.1186/s13690-021-00771-5
9. Boerma T, Campbell OMR, Amouzou A, Blumenberg C, Blencowe H, Moran A, et al. Maternal mortality, stillbirths, and neonatal mortality: a transition model based on analyses of 151 countries. Lancet Glob Health. 2023;11(7):e1024-31. doi: 10.1016/S2214-109X(23)00195-X
10. Avila J, Vásquez-Mejía A, Soto-Cabezas G, Reyes-Vega MF, Olivares N, Talavera-Romero L, et al. Neonatal mortality inequalities in Peru, 2007–2021: an ecological joinpoint trends analysis. Int J Equity Health. 2026;25(1):11. doi: 10.1186/s12939-025-02731-9
11. Copaja-Corzo C, Gomez-Colque S, Vilchez-Cornejo J, Hueda-Zavaleta M, Taype-Rondan A. Fetal death and its association with indicators of social inequality: 20-year analysis in Tacna, Peru. PLoS One. 2023;18(10):e0292183. doi: 10.1371/journal.pone.0292183
12. Avila Vargas-Machuca JG, Tavera Salazar MR, Miranda Monzon JA. Mortalidad neonatal en Perú al 2030. Proyecciones departamentales con enfoque de equidad. Rev Cuerpo Med HNAAA. 2023;16 Suppl 1:e1957. doi: 10.35434/rcmhnaaa.2023.16Supl.1.1957
13. Dol J, Hughes B, Bonet M, Dorey R, Dorling J, Grant A, et al. Timing of neonatal mortality and severe morbidity during the postnatal period: a systematic review. JBI Evid Synth. 2023;21(1):98-199. doi: 10.11124/JBIES-21-00479
14. Ávila J, Tavera M, Carrasco M. Características epidemiológicas de la mortalidad neonatal en el Perú, 2011-2012. Rev Peru Med Exp Salud Publica. 2015;32(3):423-30. doi: 10.17843/rpmesp.2015.323.1670
15. Shamba D, Day LT, Zaman SB, Sunny AK, Tarimo MN, Peven K, et al. Barriers and enablers to routine register data collection for newborns and mothers: EN-BIRTH multi-country validation study. BMC Pregnancy Childbirth. 2021;21 Suppl 1:233. doi: 10.1186/s12884-020-03517-3
16. Gupta A, Paria A. Transition from fetus to neonate. Surgery (Oxf). 2022;40(11):685-90. doi: 10.1016/j.mpsur.2022.10.001
17. Bell EF, Hintz SR, Hansen NI, Bann CM, Wyckoff MH, DeMauro SB, et al. Mortality, in-hospital morbidity, care practices, and 2-year outcomes for extremely preterm infants in the US, 2013-2018. JAMA. 2022;327(3):248-63. doi: 10.1001/jama.2021.23580
18. Haro-Norabuena RS, Gonzales-Carrillo JJ, Arce-Huamani MA. Neonatal factors associated with mortality among preterm infants admitted to neonatal intensive care in a Peruvian national hospital. Healthcare (Basel). 2025;13(19):2420. doi: 10.3390/healthcare13192420
19. Bekele GG, Roga EY, Gonfa DN, Geda GM. Incidence and predictors of mortality among neonates admitted with birth asphyxia to neonatal intensive care unit of West Shewa Zone Public Hospitals, Central Ethiopia. BMJ Paediatr Open. 2024;8(1):e002403. doi: 10.1136/bmjpo-2023-002403
20. Kawakami MD, Sanudo A, Teixeira MLP, Andreoni S, de Castro JQX, Waldvogel B, et al. Neonatal mortality associated with perinatal asphyxia: a population-based study in a middle-income country. BMC Pregnancy Childbirth. 2021;21(1):169. doi: 10.1186/s12884-021-03652-5
21. Coggins SA, Glaser K. Updates in late-onset sepsis: risk assessment, therapy, and outcomes. Neoreviews. 2022;23(11):738-55. doi: 10.1542/neo.23-10-e738
22. Care of Preterm or Low Birthweight Infants Group. New World Health Organization recommendations for care of preterm or low birth weight infants: health policy. EClinicalMedicine. 2023;63:102155. doi: 10.1016/j.eclinm.2023.102155
23. Hoeijmakers F, Beck N, Wouters MWJM, Prins HA, Steup WH. National quality registries: how to improve the quality of data? J Thorac Dis. 2018;10 Suppl 29:S3490-9. doi: 10.21037/jtd.2018.04.146
24. Stirling RG, Ahern S, Millar J, Evans S, Dawkins P, Zalcberg J. Clinical quality registries: establishing the socio-technical infrastructure for learning health systems. Learn Health Syst. 2025;9(4):e70036. doi: 10.1002/lrh2.70036