Neonatal Mortality in Jordan: Rate, Determinants, and Causes Using Jordan Stillbirth and Neonatal Surveillance System

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Abstract

Background It has been estimated that 27.8 million neonates will die between 2018 and 2030 if no improvements in neonatal mortality take place. The aim was to determine the rate, determinants, and causes of neonatal mortality in Jordan.

Methods In August 2019, an electronic stillbirths and neonatal deaths surveillance system (JSANDS) was established in in three large cities through five hospitals. Data on all births, neonatal mortality and their causes, and other characteristics in the period between August 2019 – January 2020 were exported from the JSANDS and analysed.

Results A total of 10328 births were registered in the study period, with a rate of 14.1 deaths per 1000 LBs; 76% were early neonatal deaths and 24% were late deaths. 25%of all deaths occurred in the first day of life. Multivariable analysis showed that the odds of neonatal deaths was 20.8 (95% CI 2.8,153.1) in Ministry of Health hospitals compared to private hospitals, OR 31.8 (95% CI 18.8,53.8) for very low birth (< 1500gram) neonates, OR 13 (95% CI 7.8,21.6) in preterm births compared to full-term births, and OR 2.7 (95% CI 1.2,6.0) among housewives compared to employed women. Main causes of neonatal deaths that occurred pre-discharge were respiratory and cardiovascular disorders (43%) and low birthweight and preterm (33%). The main maternal conditions that attributed to these deaths were complications of the placenta and cord, complications of pregnancy, and medical and surgical conditions. The main cause of neonatal deaths that occurred post-discharge were low birthweight and preterm (42%).

Conclusions The rate of neonatal mortality have not decreased since 2012 and the majority of neonatal deaths occurred could have been prevented. Regular antenatal visits, in which any possible diseases or complications of pregnant women or foetal anomalies, need to be fully documented and monitored with appropriate and timely medical intervention to minimize such deaths.

Background

Neonatal mortality is a public health problem worldwide primarily in developing countries. Although extensive progress has been completed in reducing neonatal mortality over the last three decades, increased efforts to improve progress are still needed to achieve the 2030 SDG target.[1] Even though there is a global decrease in neonatal mortality, the rate of decrement is considerably lower than that of the post neonatal under five mortalities.[2]

It has been estimated that 27.8 million neonates will die between 2018 and 2030 if no improvements in neonatal mortality take place.[1] A study conducted in 186 countries revealed that the risk of early neonatal death is very high across a range of countries and contexts.[3] Of all neonatal deaths, about half occurred within 24 hours of birth and around one third occurred in the first 6 hours after birth.[4] According to the Jordan Perinatal and Neonatal Mortality study, the neonatal mortality rates (NMR) was14.9 per 1,000 live births (LB).[5]

In developing countries, the majority of neonatal deaths occur without a clear cause of death (i.e. preterm).[6, 7] It is difficult to confirm the cause because there are many factors that could be linked to the exact underlying cause of neonatal mortality, however, literature has categorized causes into those related to maternal or foetal conditions.[8] Neonatal deaths often occur due to an illness presenting as an emergency, either soon after birth or later, due to infections such as tetanus or community-acquired infections.[9] Data on causes of neonatal deaths and the timing around neonatal deaths are often sparse and less reliable than all-cause mortality data, and these data result in uncertain estimates, which poses substantial challenges to the generation of evidence-based interventions to prevent neonatal deaths. Improved data on where and when neonatal death occur and what causes delays is key to designing context-specific community and strategies.[9]

One of the most powerful predictors of neonatal mortality is gestational age at birth.

There is a significant variation in mortality between babies born at 24 weeks and those born at full term,[10] reflecting the great impact of immaturity on newborn survival. An exposure that increases preterm births will therefore increase neonatal mortality. Other causes of neonatal death are congenital malformations, birth trauma, birth asphyxia, and hospital-acquired infection.[11, 12] Batieha and colleagues (2016) national study also has shown a number of maternal and neonatal risk factors of neonatal mortality (NNM). These risk factors included preterm, low birthweight, maternal age < 20 years, history of neonatal death or stillbirth, preeclampsia, scarce antenatal care, congenital anomalies, and gestational age before 37 weeks.[5]

Assessing the magnitude and aetiology of these important events and predicting its risk factors begin with accurately defining and reporting perinatal deaths.[13, 14]

A strategy for regionalized and cohesive perinatal network should be developed [15, 16] to reduce perinatal morbidity and mortality and improve survival for preterm infants and other high-risk newborns. Mortality data should be available by geographical area, rural or urban, place of death, timing, underlying cause, and other data such as socio-economic status.[17] This can help stakeholder to detect priorities and plan and monitor progress.

The scarcity of data in Jordan on neonatal mortality, especially early mortality is generally linked to the fact of that some births are not registered.[15, 16] In addition, the existing sources of data on neonatal mortality are likely to be biased. In the absence of reliable and standardised vital registration and administrative data in many countries, modelling of NMR remains necessary for public health policy and priority setting and monitoring. Around 30% of children younger than 5 years do not have a birth certificate,[18] and the majority of neonatal deaths do not obtain a death certificate.[19] Therefore, improving a reporting system of neonatal deaths is critical for tracking progress and taking appropriate actions.

As a result of this limitation, an electronic stillbirths and neonatal deaths surveillance system (JSANDS) was developed and established in five large hospitals in Jordan in August 2019. JSANDS was developed as a secure on-line data entry system to collect, organize, analyse, and disseminate reliable data on neonatal deaths, and related causes. Additionally, the system registers births to use them as a denominator for mortality measures.[20] The definition of the stillbirths and neonatal deaths used in the system were based on the international standards set by the World Health Organization and CDC. The current study utilized the data from JSANDS to determine the rate, determinants, and causes of neonatal mortality in Jordan.

Methods

Study population

The information on all births and related outcomes that registered in the JSANDS surveillance system from August 2019 to January 2020 were retrieved and analysed. All births and neonatal deaths occurred in the five selected hospitals were completely registered. Of the five hospitals, one was a university teaching hospitals, one was private, and three were public from three major governorates in Jordan. The extracted data included sociodemographic characteristics of the mother and father, birth data (i.e. gestational age, mode of delivery, and multiplicity), the newborn data (status, birthweight) and causes of neonatal deaths. In the current study, neonatal mortality was defined as any death that happened within the first 28 days of life. NMR was calculated as the number of neonatal deaths per 1000 LB.

Causes of neonatal deaths were identified according to the International Classification of Diseases-Perinatal Mortality (ICD-PM), which is part of the 10th version of the International Classification of Diseases (ICD-10) and report perinatal deaths.[21] A training was held in the five hospitals for all healthcare providers on how to assign cause of death. The doctor (usually paediatrician) who is responsible for the follow up of the neonate has the primary responsibility to fill the form for the death, assign the cause of death, and write the ICD-10 code accordingly. The ICD-10 codes were used to provide a unified language for reporting and monitoring diseases allowing a standardized comparison and sharing of data among the five hospitals.

Causes of deaths related to foetal/neonatal condition or related to maternal condition were registered. First, the main disease or condition in the newborn is identified, in which the main disease or condition of the newborn who has died is entered. Other diseases or conditions in the newborn were also reported, if any. The main underlying maternal disease or condition affecting the newborn that contributed mostly to the neonatal death was then reported.

Data analysis

The IBM SPSS version 24 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp) was used for data analysis. Data were described using rates and percentages for categorical data and means and standard deviations for continuous variables.

The NMR was calculated as the number of neonatal deaths by 1000 LB. The distribution of neonatal deaths according to studied characteristics were tested using Chi-square test. Multivariable analysis using binary logistic regression was used to determine factors associated with neonatal mortality. A *p*-value of less than 0.05 was considered statistically significant.

Results

Women's demographic and maternal characteristics

During the period from August 2019 to January 2020, a total of 9983 women gave birth to 10328 babies. The women's age ranged between 15 and 48 years with a mean (SD) of 29.1 (6.1) year. The majority of women (81%) were between 19 and 35 years of age, 2.5% were younger than 19 years and 16.5% were older than 35 years. More than half of women (55%) had high school education or less. Almost three quarters (74%) of women had income < 5000 JDs. The majority of women were housewives (90%). The rate of caesarean section rate was 49% (27% planned CS and 22% emergency CS). Table 1 shows the sociodemographic and maternal characteristics of women. A total of 973 (10%) women delivered preterm. Of total births, 297 (3%) were < 1500 grams and 1013 (9) were 1500–2499 grams. Of neonatal deaths, 76% were early neonatal deaths and 24% were late neonatal deaths.

Table 1
The sociodemographic and maternal characteristics of women

Variables	n	%
Hospital		
Private	1814	18
Teaching	1447	14
Ministry of Health	7067	68
Mother age (year)		
≤18	255	3
19–35	8377	81
>35	1696	16
Mother Education Level		
High school or less	5702	55
Diploma	711	7
Bachelor	2502	24
Master or higher	259	3
Unknown	1154	11
Total Income (JD)		
<500	7633	74
500-<1000	1718	17
≥1000	217	2
Unknown	760	7
Working status		
Housewife	9265	90
Employed	1063	10
Mode of delivery		
Vaginal	5138	50
Planned CS	2849	28
Emergency CS	2282	22

Variables	n	%
Multiplicity		
Single	9777	95
Twin	457	4
Triplet	43	.4
Quadruplet	8	.1
Gestational age		
Full-term	9199	89
Preterm	1129	11
Death age categorized		
< 7 days	109	76
> 7 days	35	24

Newborns' characteristics

A total of 10328 (10226 LB and 102 stillbirths) were registered in the five hospitals (68.4% from the three MOH hospitals, 14% from the teaching hospital, and 18% from the private hospital). Of all births, 46% were females. Almost 95% of total births were singleton, 87% weighed 2500 grams or more, 10% weighed 1500–2499 grams, and 3% weighed less than 1500 grams. Almost 76% of deaths occurred before 7 days of birth. About 89% of births were full-term and 11% were preterm. The majority of women (81%) were between 19–35 years of age, 3% aged less than 18 years.

Neonatal mortality rate NMR

Of the total 10226 LB, 144 were neonatal deaths. The overall NMR rate was 14.1 per 1000 LB. Of all deaths, 25% occurred in the first day, 19% in the second day, 16% in the third day, 3% in the fourth day, 7% in the fifth day (Fig. 1). After day 11 (3%), the rate of death sharply decreased until it reached 1% in day 28 after birth.

Table 2 shows the NMR according to the maternal, clinical and relevant characteristics. The NMR per 1000 LB varied significantly according to mother's educational level, multiplicity, birthweight, mode of delivery, and gestational age. However, the neonatal deaths did not vary significantly according to health sector and mother's age, income, and working status.

Table 2
neonatal mortality rate according to the sociodemographic, maternal, clinical and relevant characteristics of women and births' characteristics

Variables	Live births (n)	Number of deaths	Neonatal death rate per 1000 live births	*p*-value
Hospital				0.000
Private	1795	1	.6	
Teaching	1432	16	11.2	
Ministry of Health	6999	127	18.1	
Mother age (year)				0.737
≤18	253	3	11.9	
19–35	8288	114	13.8	
>35	1685	27	16.0	
Mother Education Level				0.028
High school or less	5643	92	16.3	
Diploma	709	9	12.7	
Bachelor	2476	20	8.1	
Master or higher	259	2	7.7	
Unknown	1139	21	18.4	
Total Income (JD)				0.119
<500	7558	112	14.8	
500-<1000	1699	15	8.8	
≥1000	215	2	9.3	
Unknown	754	15	19.9	
Working status				0.015
Housewife	9174	138	15.0	
Employed	1052	6	5.7	
Mode of delivery				0.000
Vaginal	5134	44	8.6	
Planned caesarean section	2836	23	8.1	

Variables	Live births (n)	Number of deaths	Neonatal death rate per 1000 live births	*p*-value
Emergency caesarean section	2254	76	33.7	
Multiplicity				0.000
Single	9692	113	11.7	
Twin	446	25	56.1	
Triplet	40	2	50.0	
Quadruplet	5	1	200.0	
Birthweight (gm)				0.000
<1500	259	80	308.9	
1500–2499	980	32	32.7	
≥2500	8987	32	3.6	
Gestational age				0.000
Full-term	9164	30	3.3	
Preterm	1062	114	107.3	
Gender of baby				0.217
Female	4740	59	12.4	
Male	5482	84	15.3	

Determinants of NMR

Multivariable analysis - Table 3- showed that the odds of deaths in MOH hospitals were almost 21 times higher than that in private hospitals, OR 20.8 (95% CI 2.8,153.1). The odds of death among very low birthweight (< 1500) were 31.8 (95% CI 18.8,53.8) higher than those with birthweight ≥ 2500grams. Also, preterm infants were significantly more likely (OR 13.0; 95% CI 7.8,21.6) to die during the neonatal period compared to full-term babies.

Table 3
Multivariable analysis of factors associated with neonatal mortality

	OR	95% Confidence Interval		p-value
Birthweight				
<1500	31.8	18.8	53.8	< 0.000
1500–2499	2.4	1.4	4.3	< 0.002
≥2500	1.0			
Gestational age				
Preterm	13.0	7.8	21.6	< 0.000
Full-term	1.0			
Delivery Hospital				< 0.001
Private	1.0			
Teaching	4.1	0.5	32.1	0.179
MOH	20.8	2.8	153.1	< 0.003
Mother Occupation				
Housewife	2.7	1.2	6.0	0.019
Employed	1.0			

The odds of neonatal mortality was significantly higher among babies born to housewives compared to those who were born to employed women (OR 2.7; 95% CI 1.2,6.0).

Causes of neonatal mortality

Table 4 shows the main causes of neonatal deaths in Jordan. The main leading cause of death was respiratory and cardiovascular disorders which contributed to 43% of pre-discharged deaths and 33% of post-discharged deaths. The second leading cause of death was low birthweight and preterm which contributed to 33% of pre-discharged deaths and 42% of post-discharged deaths, followed by congenital malformation deformations and chromosomal abnormalities which contributed to 19% of pre-discharged deaths and 8% of post-discharged deaths.

Table 4
Main causes of pre-discharged and post-discharged neonatal mortality

Foetal causes	**Pre-discharged N (%)**	**Post-discharged N (%)**
N1-Congenital malformations and chromosomal abnormalities	23 (19%)	1 (8%)
N2-Disorders related to foetal growth	0(0%)	1 (8%)
N3-Birth trauma	1(1%)	0 (0%)
N4-Complications of intrapartum events	3(3%)	0 (0%)
N5-Convulsions and disorders of cerebral status	1 (1%)	0 (0%)
N6-Infection	1 (1%)	0 (0%)
N7-Respiratory and cardiovascular disorders	51 (43%)	4 (33%)
N8-Other neonatal conditions	1(1%)	1 (8%)
N9- Low birthweight and preterm	39(33%)	5 (42%)
Total	120 (100%)	12 (100%)
Maternal causes		
M1-Complications of placenta cord and membranes	17 (55%)	1 (100%)
M2-Maternal complications of pregnancy	8 (26%)	0 (0%)
M3-Other complications of labour and delivery	1 (3%)	0 (0%)
M4-Maternal medical and surgical conditions	5 (16%)	0 (0%)
Total (%)	31(100%)	1 (100%)

For the main maternal diseases or conditions affecting foetus/infant, the most common reported condition was complication of placenta, cord, and membrane which contributed to 55% of the 31 deaths that had maternal causes, followed by maternal complications of pregnancy, and lastly maternal medical and surgical conditions.

Discussion

Principal findings

The current study utilized the data from the JSANDS to determine the rate, determinants, and causes of neonatal mortality in Jordan. This study indicated that the NMR per 1000 LB was 14.1 (13.9 deaths per 1000 total births), and it varied significantly according to mother's educational level, multiplicity, birthweight, mode of delivery, and gestational age. Additionally, the main leading cause of neonatal death was respiratory and cardiovascular disorders, followed by congenital malformation and chromosomal abnormalities. The second leading cause of death was low birthweight and preterm. The most common maternal condition was complication of placenta, cord, and membrane, followed by maternal complications of pregnancy, and lastly maternal medical and surgical conditions. Mode of delivery was a significant factor in our study. While there were no significant differences in NMR between vaginal delivery and planned CS, emergency CS was associated with higher NMR.

Interpretation

The neonatal death rate in the current study is almost similar to the Jordan Perinatal and Neonatal Mortality study using the same cut-off point of gestational weeks (>= 20 weeks) [5] indicating that the rate has flatten since 2015 and has not shown a significant decline. Despite the tremendous efforts and improved NMR outcome since 1990, still more work is needed to accomplish the Sustainable Developmental Goal by 2030, particularly in regions with high NMR [1] including Jordan.

The main leading cause of neonatal death in the current study was respiratory and cardiovascular disorders followed by congenital malformation and chromosomal abnormalities, and these are similar to the findings in Batieha et al., study (2016) in which congenital anomalies was a leading cause of death.[5] Literature revealed that although several congenital anomalies could be avoided, they still are important causes of neonatal deaths.[22] Congenital malformation was reported constantly across many classification systems,[23] which could be preventable by prenatal folic acid with multivitamin supplements that is proved to decrease the incidence of congenital abnormalities such as neural tube defects.[24, 25]

Although the current study did not look at the association between Apgar score and NMR, it is expected that respiratory and cardiovascular disorders that contributed to higher neonatal deaths in our study were indirectly related to low Apgar score. Previous studies showed that Apgar score was low in babies with neonatal infections, asphyxia related complications, meconium aspiration respiratory distress, and neonatal hypoglycaemia.[26, 27]

Neonatal deaths often happen quickly, caused by an illness presenting as an emergency, either soon after the birth or later, due to infections.[9]

Similar to our findings which showed that the second leading cause of death was low

birthweight and preterm, previous studies also showed that a strong predictor of neonatal death is immaturity as usually reflected by the age in gestational weeks at birth. Neonatal mortality can differ significantly between preterm babies and their counterparts full-term infants born at 39–40 weeks of gestation.[10] Moreover, the findings of the national Jordan Perinatal and Neonatal Mortality study [5] are congruent with our findings where preterm, gestational age before 37 weeks, low birthweight, multiple pregnancy were the most common risk factors associated with neonatal deaths. Low birthweight may result from both foetal growth restriction and preterm birth, which are associated with placental dysfunction and subsequent poor foetal outcomes.[17] Likewise, a study conducted in 60 low and middle income countries found that NMR was significantly higher among twins versus singleton newborn babies even after adjusting for birthweight.[28] Another study in Bangladesh found that NMR was much higher among newborn babies born before 34 gestational weeks, twins or triplets, and first child in the family.[29]

Mode of delivery was a significant factor in our study in which emergency CS was associated with higher NMR. Previous studies showed that caesarean section rates higher than 10% are not associated with reduction in NMR, and hence should be avoided as much as possible.[30] It is worth mentioning that the NMR has increased significantly in the last three decades including Jordan, surpassing the WHO recommendations of 10–15% CS as the maximum rates.[31, 32]

Interestingly, the current study showed that NMR did not vary significantly according to mother's age, income, and working status but mother's high school or less of education was associated with higher rates of neonatal deaths. Incongruent with our findings, maternal age of 30–35 years was associated with higher NMR.[29, 33] The latest national study showed that maternal age < 20 years was associated with higher rates of neonatal deaths.[5] However, some research suggested that advanced maternal age is associated with placental dysfunction that may increase the risk of neonatal deaths and stillbirths[34] or to existing maternal medical condition.[35] Also, newborn babies of richer families who also have a high educational level have higher chances to survive than those born to a poor family with lower educational level.[36]

Despite the fact that the majority of neonatal deaths can be prevented with efficient interventions,[37] some disadvantaged women and newborns who are most vulnerable to death and chronic morbidity have poor access to quality healthcare services.[19, 38] Nonetheless, understanding the social and geographical pattern of NMR is crucial for stakeholders to increase access to effective interventions with focus on the poorest populations.[19, 39] This will ensure that every pregnant woman and newborn baby have equal access to lifesaving interventions.[40]

For the main maternal diseases or conditions affecting infants, the most common reported condition in the current study was complication of placenta, cord, and membrane, followed by maternal complications of pregnancy, and lastly maternal medical and surgical conditions. Placental dysfunction is linked to intrauterine growth restriction, preterm birth, and birth defects[41] resulting in inadequate oxygen supply to the foetus and thus increasing the probability of preterm births and/or low birthweight. Our findings are somehow congruent with the 2016 national study that revealed maternal diseases such as preeclampsia, mother's hospitalization during the current pregnancy, and poor antenatal care can all lead to neonatal deaths. It is surprising that in the national study, only a third of neonatal deaths had received optimum medical care.[5] Other studies conducted in low-middle-income countries like Pakistan have also specified several contributing factors to neonatal deaths such as inadequate training, insufficient medical care, low competence of healthcare providers and a lack of resources.[42] Nonetheless, the national study showed also that a large proportion of neonatal deaths are preventable or possibly preventable thus providing optimal intrapartum, and direct postpartum care is likely to result in reduction of NMR.[5]

However, not all births are registered in Jordan, especially if the birth results in stillbirth or early neonatal death before discharge from the hospital and the majority of neonatal deaths are not reported either.[15,16] About 30% of children < 5 years do not have a birth certificate,[18] and parents do not usually issue a death certificate for the majority of neonatal deaths.[19] Thus, there is a lack of credible data on causes of stillbirths and neonatal deaths than all-cause mortality data, hindering the development of appropriate interventions to avoid such deaths. The current study fills the gap in such data and hence, encourage stakeholders and policy makers to design and implement timely, evidence-based interventions to regions that register high number of stillbirths and neonatal deaths.

In the current study, having a NMR of 14.1 per 1000 total LB highlights an immediate attention to accelerate appropriate efforts to prevent such deaths. This is vital as recent literature reported that with no improvements in neonatal mortality, 27·8 million neonates will die in the period from 2018 to 2030.[1] Yet, if policy makers initiate and implement interventions and improve quality of care to the point that NMR - in the countries that are still behind- would match the SDG target, then 5 million newborn babies could survive. A particular emphasis need to be towards births because a third of all neonatal deaths occur on the day of birth globally and about three-quarters of neonatal deaths occur during the first week of life.[19,43]

Strengths of the study

The information collected on all births and related outcomes in this study were extracted from the JSANDS surveillance system, which is a secure on-line data entry system developed specifically to collect, organize, analyse, and disseminate reliable data on neonatal deaths, and related causes. Every birth and neonatal death occurred in the five selected hospitals were completely and accurately registered through the JSANDS to overcome the problem of lack of registration to stillbirths and neonatal deaths. The research team verified the deaths registered through the JSANDS with those documented on paper and electronic medical records in the hospital to avoid any missing death.

Causes of neonatal deaths were identified according to the ICD-PM. We chose the codes to provide a unified language for reporting and monitoring deaths, thus allowing a standardized comparison and sharing of data among the five hospitals. Furthermore, a specialized training was held in the recruited hospitals for all healthcare providers on how to assign cause of death to ensure accurate and reliable data.

Limitations of the data

The JSANDS system did not include all hospitals in Jordan, and this could have limited the generalizability of the findings at a national level. The data exported from the JSANDS for this study were over a period of six months, which could have hindered estimating the accurate NMR in Jordan. Analysing the data over a longer period is expected to provide more reliable rates.

Conclusion

The rate of neonatal mortality did not decrease since 2012 and that NMR has flatten since the last national study urging the need to design and implement evidence-based interventions to mothers and newborn babies who most need it. The majority of neonatal deaths occurred in the current study could have been prevented with regular antenatal visits, in which any possible diseases or complications of pregnant women or foetal anomalies need to be fully documented and monitored with appropriate and timely medical intervention to minimize such deaths. Specialized care provided to low birthweight neonates and those with respiratory problems by experienced healthcare providers is vital. Finally, the current study reported the findings of NMR extracted from a national neonatal and stillbirth surveillance system. As the majority of neonatal deaths are not reported in Jordan, investing in the health information systems to improve data registration will encourage appropriate use of interventions to reduce NMR.

Declarations

Ethics approval and consent to participate: The study was ethically approved by the Institutional Review Board (IRB) at Jordan University of Science and Technology and the Ministry of Health in Jordan. The data used in this manuscript was retrieved electronically from the JSANDS surveillance system (www.jsands.jo).

Consent for publication: Not applicable

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

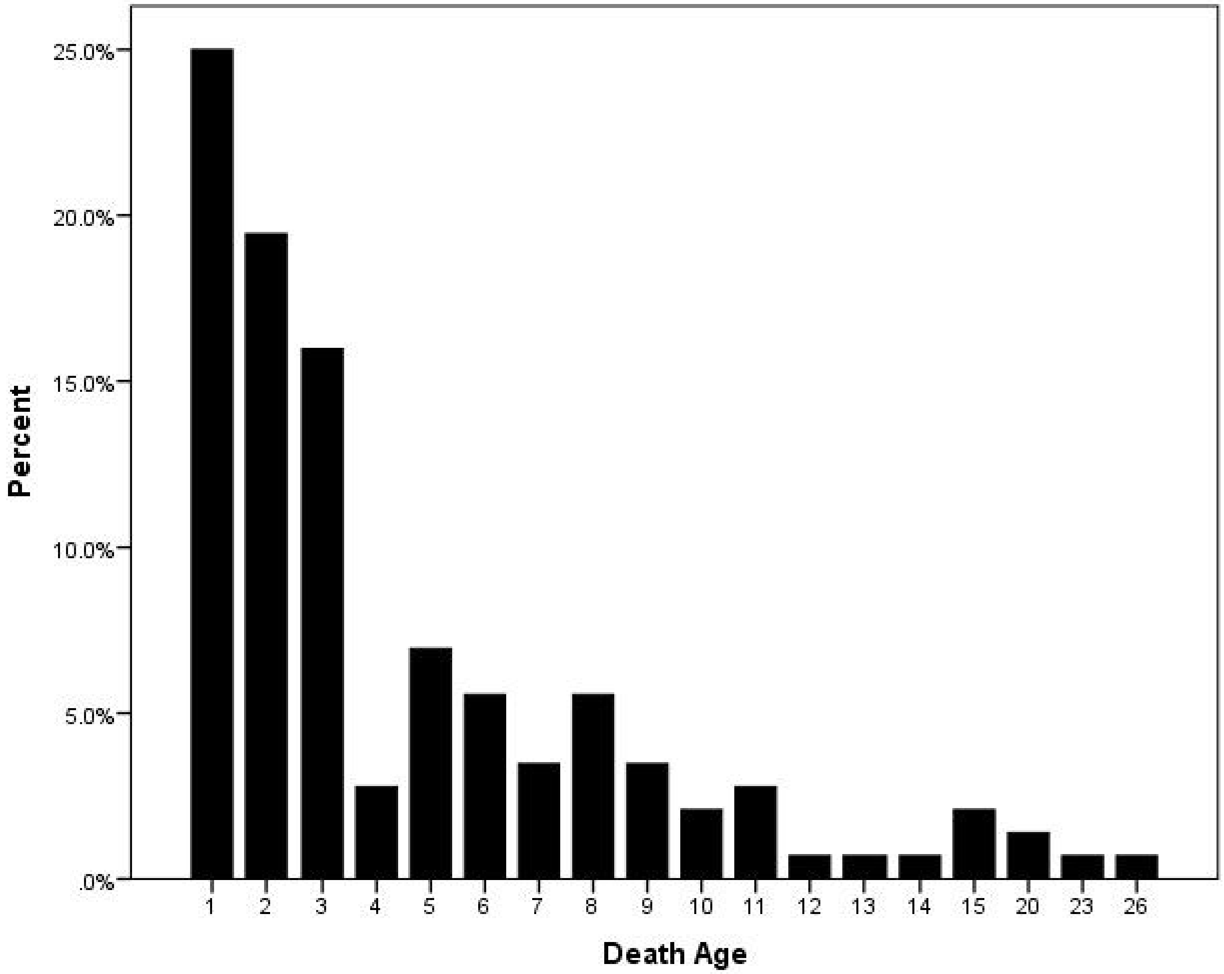

Figure 1

Neonatal death percentages according to age in days