Iran J Pediatr. 2024 April; 34(2):e143632. https://doi.org/10.5812/ijp-143632.

Published online 2024 March 16. **Research Article**

Rates and Causes of Neonatal Mortality In North-West of Iran

Marjan Hosseinpour [1, 2], Farzad Maleki [1, 3], Hamidreza Farrokh-Eslamlou [4], Zahra Sahebazzamani [5], Javad Aghazadeh [6], Rasoul EntezarMahdi [1], Zahra Ahmadnezhad [5] and Shahsanam Gheibi [5, *]

[1] Social Determinants of Health Research Center, Clinical Research Institute, Urmia University of Medical Sciences, Urmia, Iran
[2] Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Science, Teran, Iran
[3] Department of Epidemiology, School of Public Health & Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[4] Reproductive Health Research Center, Clinical Research Institute, Urmia University of Medical Sciences, Urmia, Iran
[5] Maternal and Childhood Obesity Research Center, Urmia University of Medical Sciences, Urmia, Iran
[6] Department of Neurosurgery, Faculty of Medicine, Tabriz University of Medical Sciences, Tabriz, Iran

[*] *Corresponding author*: Maternal and Childhood Obesity Research Center, Urmia University of Medical Sciences, Urmia, Iran. Email: gheibi1345sh@gmail.com

Received 2023 December 09; **Revised** 2024 January 22; **Accepted** 2024 January 31.

Abstract

Background: The neonatal mortality rate (NMR) is a crucial indicator of a country's population health
Objectives: This study aims to assess the rates and causes of NMR in West Azerbaijan.
Methods: This population-based cross-sectional study utilizes data from the Child Mortality Surveillance System (CMSS) spanning from 2013 to 2022. The study population comprised all neonates (< 28 days old) with permanent residency in any of the 17 cities within the West Azerbaijan province who died within the stated period. Mortality rates, both all-cause and cause-specific, were determined per 1 000 live births for the years 2013, 2016, and 2022.
Results: The investigation covered 3 689 reports of neonatal deaths (< 28 days old) from 2013 to 2022. Of these, 53% were males, with an average gestational age of 31.85 ± 5.56 weeks. Over 72% of the deaths occurred in preterm infants, and 69% were linked to cesarean section deliveries. Perinatal prematurity was the leading cause of death during the periods examined, with rates of 32.3%, 35.2%, and 36.8% in 2013, 2016, and 2022, respectively. The distribution of neonatal mortality across the province was uneven, with Poldasht city experiencing the highest mortality rates and Shot city the lowest (9.13 and 2.89 per 1 000 live births, respectively).
Conclusions: West Azerbaijan province has achieved the Health-related Sustainable Development Goal (SDG-3) of reducing neonatal mortality to below 12 deaths per 1 000 live births by 2030. Nonetheless, significant disparities in NMR persist across the province. Further epidemiological research and the development of targeted health programs are essential to address areas with elevated mortality rates.

Keywords: Neonatal, Mortality Rate, Iran

1. Background

The efficiency of a country's healthcare system is assessed by many factors, with one of the most crucial being neonatal mortality (1). Neonatal mortality is defined as the death of a newborn within the first 28 days of life (2). The neonatal mortality rate (NMR) in communities has decreased due to economic and social developments and the implementation of effective interventions. According to the second target of the Health-related Sustainable Development Goals (SDG-3), countries worldwide committed to reducing the NMR to 12 deaths per 1 000 live births by 2030 (3, 4). Previously, reducing infant mortality by two-thirds between 1990 and 2015 was one of the Millennium Development Goals (MDGs) adopted voluntarily by 189 countries (5).

There are numerous indices to measure child mortality rates, including the under-five child mortality rate (U5MR), NMRs, child mortality rates (CMRs), and infant mortality rates (IMRs) (6). In 2015, there were 2.7 million cases of NMR worldwide, accounting for 45% of all deaths in children under 5 years of age (7). Reports indicate that upper-middle-income countries experienced a substantial 73% decrease in NMR from 1990. In contrast, low-income countries exhibited a lower decrease of 45%, highlighting the need for further improvements in these regions (8).

A wide range of studies have revealed that the most common causes of neonatal mortality in developing countries are infectious diseases, asphyxia, and congenital disorders (9, 10). According to the World Health Organization (WHO), preterm birth accounts for 30%

of neonatal deaths worldwide, sepsis or pneumonia 27%, asphyxia 23%, birth defects 6%, neonatal tetanus 4%, diarrhea 3%, and other causes contribute to 7% of all neonatal mortality (11). In the past decade, neonatal mortality has significantly declined, largely due to decreases in deaths caused by 2 main factors: birth asphyxia (34% of total reductions) and prematurity (21%) (12).

To achieve the Sustainable Development Goals (SDGs), it is crucial to identify and update factors affecting NMR through applied research. Several studies have been conducted in Iran and other countries to determine the factors influencing NMR (13-17); however, there is no comprehensive research on the West Azerbaijan province in Iran.

2. Objectives

In this study, we aimed to investigate the rates and causes of NMR in West Azerbaijan to provide local policymakers with data for designing effective strategies to accelerate the reduction of neonatal mortality.

3. Methods

3.1. Data Sources

We conducted a population-based cross-sectional study using data from the Child Mortality Surveillance System (CMSS) in West Azerbaijan province, Iran. The target population comprised all children under 28 days of age who were permanent residents of West Azerbaijan and who died between 2013 and 2022. Data were obtained from the CMSS conducted by the West Azerbaijan University of Medical Sciences, which is designed to be provincially and regionally representative. The system covers all deaths of children under 28 days old in all 17 counties (Shahindezh, Poldasht, Tekab, Shot, Maku, Urmia, Khoy, Naqadeh, Mahabad, Salmas, Oshanvieh, Chaldoran, Miandoab, Sardasht, Chaypareh, Piranshahr, Bukan). The study was approved by the Ethical Committee of Urmia University of Medical Sciences (No: IR.umsu.rec.1395.450) and the WHO Regional Office for the Eastern Mediterranean.

3.2. Procedures

To compile a comprehensive database, we collected data on various aspects of the neonates, including their age at death, gender, date and place of death, delivery type, and gestational age, in order to create a worklist for each deceased case. The NMR was calculated as the number of deaths within 28 days from birth per 1 000 live births during the same time period. Neonatal deaths were categorized as early neonatal deaths (within 7 days after birth), late neonatal deaths (deaths between 7 and 27 days after birth), and post-neonatal deaths (occurring 28 days after birth). Additionally, preterm birth was defined as infants born alive earlier than 37 weeks of pregnancy, full-term birth was classified as birth occurring between 37 and 42 weeks, and infants born after 42 weeks were considered post-term. Statistical analyses were performed using SPSS (version 21.0, SPSS Inc., Chicago, Illinois, USA). The resulting data were recorded in Microsoft Excel 2019 and analyzed using descriptive statistics (mean ± SD) and No. (%).

4. Results

In this study, a total of 3,689 immediate reports of neonatal deaths (< 28 days) were investigated from 2013 to 2022. Among them, 52.97% were males, with an average gestational age of 31.85 ± 5.56 weeks. Of the total deaths, over 72 percent occurred in preterm infants, and 69 percent were associated with cesarean section deliveries. In both genders, most deaths occurred in the hospital, with death at home ranking second, and a lower percentage of deaths occurred during dispatch (Table 1).

In total, neonatal deaths from 17 major causes were reported (Table 2). The top four primary causes were perinatal prematurity (32.3%), perinatal cardiovascular and respiratory disorders (25%), chromosomal and congenital disorders (15.3%), and perinatal hematologic and hemorrhagic disorders (10.9%) in 2013. While the order of diagnosis was similar in 2022, it became perinatal prematurity (36.8%), perinatal cardiovascular and respiratory disorders (14.6%), perinatal hematologic and hemorrhagic disorders (13.5%), and chromosomal and congenital disorders (8.7%) (Table 2).

Neonatal mortality is unevenly distributed across cities within the West Azerbaijan province (different cities within the Urmia University of Medical Sciences), with the highest mortality rate in Poldasht city (9.13 per thousand live births) and the lowest mortality rate in the city of Shot (2.89 per thousand live births). The trend in mortality rates in cities also shows that in cities like Poldasht, Piranshahr, and Urmia, an increasing trend is observed from 2013 to 2022 (Figure 1).

Based on the data depicted in Figure 2, it can be observed that the NMR from 2013 to 2022 has demonstrated slight fluctuations. The NMR has ranged between 7 and 8.6 during this period. The recorded rates for each year are as follows: 8.1, 8.6, 7.9, 8, 8.2, 8, 8.3, 8.4, 7.7, and 7. Overall, there is a general pattern of minor variations, with some years showcasing a slight increase or decrease in the NMR.

Table 1. Characteristics of Neonatal Mortalities in West Azerbaijan From 2013 to 2022 [a]

Variables	Male	Female
Total Number	1957	1732
Gestational age		
Preterm	969 (73.3)	756 (72.4)
Full term	346 (26.1)	287 (27.5)
Post-term	7 (0.5)	1 (0.001)
Death age (day)		
Early neonatal death	1289 (76.2)	989 (74.7)
late neonatal death	378 (23.4)	319 (24.1)
Post neonatal death	23 (1.4)	15 (1.2)
Delivery types		
Caesarean	1318 (69.7)	984 (68.4)
Natural	571 (30.2)	454 (31.5)
Death places		
Hospital	1803 (95.4)	1375 (94.3)
Home	59 (3.1)	61 (4.2)
During dispatch	28 (1.5)	21 (1.5)

[a] Variables are expressed as No. (%).

Table 2. The Distribution of Causes of Neonatal Mortality in West Azerbaijan Province, 2013, 2016 and 2022 [a]

Cause of Death	2013	Cause of Death	2016	Cause of Death	2022
Perinatal prematurity	129 (32.3)	Perinatal prematurity	127(35.2)	Perinatal prematurity	130 (36.8)
Perinatal Cardiovascular and respiratory	100 (25)	Chromosomal and congenital disorders	66 (18.4)	Perinatal Cardiovascular and respiratory	52 (14.6)
Chromosomal and congenital disorders	61 (15.3)	Perinatal hematologic and hemorrhagic disorders	50 (13.8)	Perinatal hematologic and hemorrhagic disorders	48 (13.5)
Perinatal hematologic and hemorrhagic disorders	44 (10.9)	Perinatal cardiovascular and respiratory	42 (11.6)	Chromosomal and congenital disorders	31 (8.7)
Perinatal infection	20 (5)	Other prenatal disorders	27 (7.4)	Other prenatal disorders	22 (6.2)
Other prenatal disorders	18 (4.4)	Perinatal infection	14 (4)	Cardiovascular disorders	14 (4)
Unknown	7 (1.6)	Unknown	7 (2.0)	Perinatal infection	11 (3)
Metabolic and nutritional disorder	6 (1.4)	Metabolic and nutritional disorder	6 (1.6)	Gastrointestinal disorders	8 (2.2)
Accidents	6 (1.4)	Cardiovascular disorders	5 (1.4)	Respiratory disorders	7 (2)
Cardiovascular disorders	3 (0.7)	Accidents	4 (1.2)	Nervous system disorders	7 (2)
Meconium aspiration	3 (0.7)	Meconium aspiration	4 (1.2)	Accidents	6 (1.7)
Gastrointestinal disorders	2 (0.3)	Gastrointestinal disorders	3 (0.8)	Meconium aspiration	6 (1.7)
Respiratory disorders	2 (0.3	Respiratory disorders	2 (0.5)	Unknown	5 (1.4)
Nervous system disorders	2 (0.3)	Urogenital disorders	2 (0.5)	Metabolic and nutritional disorder	4 (1.2)
Immune and hematopoietic system disorders	1 (0.2)	Immune and hematopoietic system disorders	1 (0.2)	Infectious and parasitic diseases	2 (0.56)
Infectious and parasitic diseases	1 (0.2)	Nervous system disorders	0	Immune and hematopoietic system disorders	1 (0.27)
Urogenital disorders	0	Infectious and parasitic diseases	0	Urogenital disorders	0

[a] Variables are expressed as No. (%).

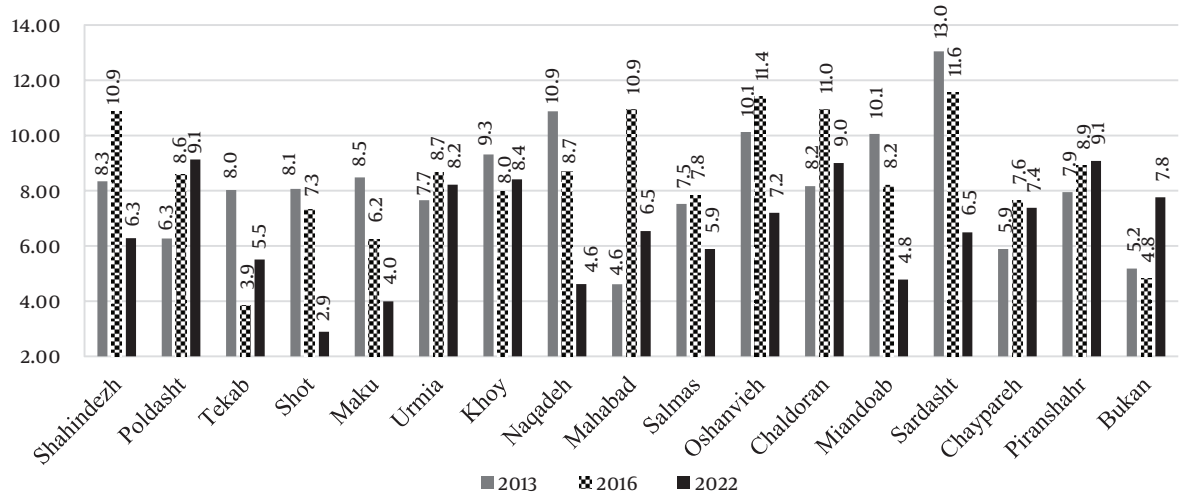

Figure 1. Trend of neonatal mortality rate in cities covered by West Azerbaijan Province, 2013, 2016, and 2022 (per 1000 live births).

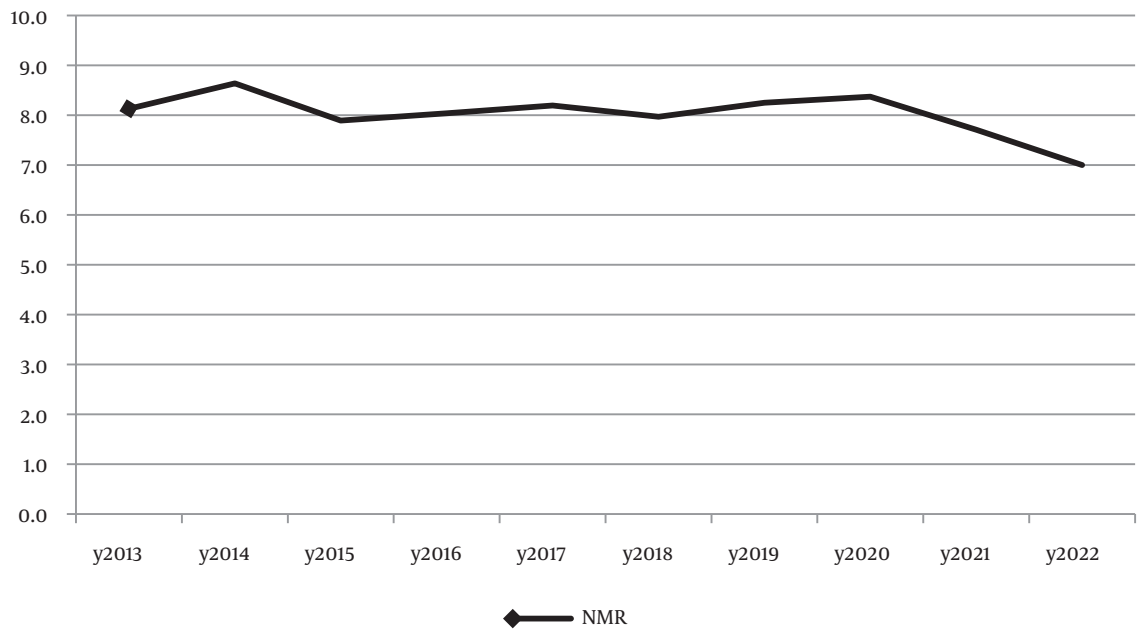

Figure 2. Trend of neonatal mortality rate in West Azerbaijan province during 2013 - 2022 (per 1000 live births).

5. Discussion

The study revealed that neonatal mortality in West Azerbaijan was 7 per 1 000 live births in 2022, marking a decrease over the previous three years. However, an assessment over 5 years revealed no significant change in mortality trends from 2018 to 2022. The Global Burden of Disease (GBD) report indicated that in 1990, the neonatal mortality rate in West Azerbaijan was 35.5 per 1 000 live births (18). Since then, the likelihood of neonatal death in the first month has decreased by 76.9% over three decades. In response, the Iranian Government's Ministry of Health and Medical Education (MOHME) has launched several nationwide health programs aimed at enhancing care for pregnant women, neonates, and infants. These include primary health care (PHC), screening for congenital

abnormalities, immunizations, the family physician plan, and prenatal diagnostic testing. Notably, West Azerbaijan province has met the SDG 3 target for neonatal mortality, which is below 12 per 1000 live births, although cities like Shahindezh and Poldasht still require targeted strategies from local policymakers to further reduce neonatal mortality.

The study also found that the mortality rate among boys (55.7%) was higher than among girls (44.3%), aligning with previous research (19, 20). Furthermore, the neonatal mortality rate (NMR) for cesarean sections was significantly higher than for vaginal deliveries, suggesting cesarean delivery as a potential risk factor for infant mortality. This is supported by population-based case-control study suggests that cesarean delivery may be considered a risk factor for infant mortality (OR = 1.97) (21). Another case-control study in Iran estimated that the risk of neonatal death in caesarean section delivery was 3.34 times higher than normal vaginal delivery (22). Similar to earlier studies conducted in Iran (23, 24), this study demonstrated that perinatal disorders such as prematurity, cardiovascular and respiratory disorders, and hematologic and hemorrhagic disorders as leading causes of neonatal death. A related study in Isfahan highlighted prematurity and congenital malformation as major contributors to NMR. Additionally, a recent study spanning from 1990 to 2019 (18) across Iran's provinces found neonatal disorders and birth defects as the leading causes of NMR (25), with preterm birth being the foremost cause of neonatal death globally, followed by congenital diseases (26).

Despite its strengths, including a population-based approach and comprehensive death coverage, our study acknowledges limitations. It lacked access to potential influencing factors on child mortality, such as birth weight, birth order, pregnancy status, prenatal and postnatal care, and socioeconomic status. The retrospective design and reliance on secondary data may have introduced data quality issues, including misclassification and classification bias. Furthermore, the potential bias from the shifting and relocation of experts in children's programs at health centers could have affected the data quality.

5.1. Conclusions

The findings of the present study indicate that, despite a convergence in trends, disparities in neonatal mortality persist across West Azerbaijan province. While the results of this study, along with those from other Iranian provinces, suggest that the SDG 3 target for neonatal mortality has been met, there remain variations in mortality rates and specific reasons for these differences among the various cities within the province, each with distinct socioeconomic conditions. This necessitates greater focus and the development of tailored intervention strategies.

Acknowledgments

We greatly appreciate the funding support of the WHO-Regional Office EMRO. This study was approved under the ethical approval code No: IR.umsu.rec.1395.450 by the Ethics Committee of Urmia University of Medical Sciences.

Footnotes

Authors' Contribution: The authors' responsibilities were as follows - M.H and J.A: conceptualization, writing and editing, and supervision; F.M and R.E: participated in study design, guidance, and review of data analysis. H.F.E and Z.S: writing - original draft preparation, methodology, software, and investigation; N.S. SH.GH: conceptualization, writing-reviewing, and editing and all authors: read and approved the final manuscript.

Conflict of Interests: There are no conflicts of interest among the authors of this study.

Data Availability: It was not declared by the authors.

Ethical Approval: The study was approved by the Ethical Committee of Urmia University of Medical Sciences (No: IR.UMSU.REC.1395.450) and the WHO Regional Office for the Eastern Mediterranean.

Funding/Support: We greatly appreciate the funding support of the WHO-Regional Office EMRO.

References

1. Oestergaard MZ, Inoue M, Yoshida S, Mahanani WR, Gore FM, Cousens S, et al. Neonatal mortality levels for 193 countries in 2009 with trends since 1990: a systematic analysis of progress, projections, and priorities. *PLoS Med*. 2011;**8**(8). e1001080. [PubMed ID: 21918640]. [PubMed Central ID: PMC3168874]. https://doi.org/10.1371/journal.pmed.1001080.
2. Titaley CR, Dibley MJ, Agho K, Roberts CL, Hall J. Determinants of neonatal mortality in Indonesia. *BMC Public Health*. 2008;**8**:232. [PubMed ID: 18613953]. [PubMed Central ID: PMC2478684]. https://doi.org/10.1186/1471-2458-8-232.
3. Helleringer S, Arhinful D, Abuaku B, Humes M, Wilson E, Marsh A, et al. Using community-based reporting of vital events to monitor child mortality: Lessons from rural Ghana. *PLoS One*. 2018;**13**(1). e0192034. [PubMed ID: 29381745]. [PubMed Central ID: PMC5790256]. https://doi.org/10.1371/journal.pone.0192034.
4. Mokari-Yamchi A, Abdollahi Z, Sadeghian-Sharif S, Nobakht-Haghighi F, Salehi-Sahlabadi A, Eini-Zinab H. Assessment of the Iodine Status Among Iranian School-aged Children 20 Years After the First National Survey in Iran. *J Compr Pediatr*. 2022;**13**(1). https://doi.org/10.5812/compreped.121588.

5. Morley CP, Wang D, Mader EM, Plante KP, Kingston LN, Rabiei A. Analysis of the association between millennium development goals 4 & 5 and the physician workforce across international economic strata. *BMC Int Health Hum Rights*. 2017;**17**(1):18. [PubMed ID: 28720089]. [PubMed Central ID: PMC5516300]. https://doi.org/10.1186/s12914-017-0126-2.
6. Black RE, Cousens S, Johnson HL, Lawn JE, Rudan I, Bassani DG, et al. Global, regional, and national causes of child mortality in 2008: a systematic analysis. *Lancet*. 2010;**375**(9730):1969–87. [PubMed ID: 20466419]. https://doi.org/10.1016/S0140-6736(10)60549-1.
7. Yazdizadeh B, Parsaeian M, Majdzadeh R, Nikooee S. Impact of Health Research Systems on Under-5 Mortality Rate: A Trend Analysis. *Int J Health Policy Manag*. 2017;**6**(7):395–402. [PubMed ID: 28812835]. [PubMed Central ID: PMC5505109]. https://doi.org/10.15171/ijhpm.2016.147.
8. Hug L, Alexander M, You D, Alkema L; UN Inter-agency Group for Child Mortality Estimation. National, regional, and global levels and trends in neonatal mortality between 1990 and 2017, with scenario-based projections to 2030: a systematic analysis. *Lancet Glob Health*. 2019;**7**(6):e710–20. [PubMed ID: 31097275]. [PubMed Central ID: PMC6527519]. https://doi.org/10.1016/S2214-109X(19)30163-9.
9. Zeinalzadeh AH, Khodaei R, Heidarzadeh M, Mirnia K. Causes of neonatal mortality in the neonatal intensive care unit of Taleghani Hospital. *Iran J Neonatol*. 2017;**8**(3):58–61.
10. Bhutta ZA, Darmstadt GL, Hasan BS, Haws RA. Community-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. *Pediatrics*. 2005;**115**(2 Suppl):519–617. [PubMed ID: 15866863]. https://doi.org/10.1542/peds.2004-1441.
11. World Health Organization. *The World Health Report 2005: Make every mother and child count*. Geneva, Switzerland: World Health Organization; 2005, [cited 2023].
12. World Health Organization. *Health in 2015: from MDGs, millennium development goals to SDGs, sustainable development goals*. Geneva, Switzerland: World Health Organization; 2015.
13. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals. *Lancet*. 2016;**388**(10063):3027–35. [PubMed ID: 27839855]. [PubMed Central ID: PMC5161777]. https://doi.org/10.1016/S0140-6736(16)31593-8.
14. G. B. D. Mortality Collaborators. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;**390**(10100):1084–150. [PubMed ID: 28919115]. [PubMed Central ID: PMC5605514]. https://doi.org/10.1016/S0140-6736(17)31833-0.
15. GBD Child Mortality Collaborators. Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*. 2016;**388**(10053):1725–74. [PubMed ID: 27733285]. [PubMed Central ID: PMC5224696]. https://doi.org/10.1016/S0140-6736(16)31575-6.
16. Karimi P, Mahmudi L, Azami M, Badfar G. Mortality in Neonatal Intensive Care Units in Iran: A Systematic Review and Meta-Analysis. *Iran J Neonatol*. 2019;**10**(3).
17. Mirfazeli A, Sedehi M, Golalipour MJ. Neonatal and prenatal causes of death in Gorgan-North of Iran. *Med J Islam Republ Iran*. 2014;**28**:43.
18. Sepanlou SG, Rezaei Aliabadi H, Naghavi M, Malekzadeh R; GBD Iran Child Collaborators. Neonate, Infant, and Child Mortality by Cause in Provinces of Iran: An Analysis for the Global Burden of Disease Study 2019. *Arch Iran Med*. 2022;**25**(8):484–95. [PubMed ID: 37543870]. https://doi.org/10.34172/aim.2022.80.
19. Rahbar M, Ahmadi M, Lornejad HR, Habibelahi A, Sanaei-Shoar T, Mesdeaghinia AR. Mortality causes in children 1–59 Months in Iran. *Iran J Public Health*. 2013;**42**(Supple1):93.
20. Humphrey L, Bello S, Rousham E. Sex differences in infant mortality in Spitalfields, London, 1750-1839. *J Biosoc Sci*. 2012;**44**(1):95–119. [PubMed ID: 21939581]. https://doi.org/10.1017/S0021932011000484.
21. Ghaedmohammadi Z, Anaraki A, Khajeian A, Khajehian M, Ostovar A. Association of caesarean section and neonatal death: a population-based case-control study in Islamic Republic of Iran. *East Mediterr Health J*. 2015;**21**(4):266–72. [PubMed ID: 26077521]. https://doi.org/10.26719/2015.21.4.266.
22. Namakin K, Sharifzadeh G, Molki Zade A. [To identify the risk factors in prematurity birth in Birjand, Iran: a case-control study]. *Iran J Epidemiol*. 2011;**7**(3):1–5. Persian.
23. Aramesh MR, Malekian A, Dehdashtian M, Shahori A, Monjezi L. [Determination of neonatal mortality causes among neonates admitted in NICU at Imam Khomeini Hospital, Ahwaz, 2011-2012]. *Razi J Med Sci*. 2014;**21**. Persian.
24. Aref Nejad M, Jaberi N, Khalili Pour E, Isfahani P. [Survey of neonatal mortality in nicu in amiralmomenin hospital of zabol university of medical sciences in 2014: A short report]. *J Rafsanjan Univ Med Sci*. 2016;**15**(1):91–8. Persian.
25. Farhat A, Saeidi R, Zegheibizadeh F, Golhasani F, Mohammadzadeh A. Causes of Death and the Mortality Rate of Newborns in NICU in Mashhad for Five Years. *Iran J Neonatol*. 2022;**13**(3).
26. Perin J, Mulick A, Yeung D, Villavicencio F, Lopez G, Strong KL, et al. Global, regional, and national causes of under-5 mortality in 2000-19: an updated systematic analysis with implications for the Sustainable Development Goals. *Lancet Child Adolesc Health*. 2022;**6**(2):106–15. [PubMed ID: 34800370]. [PubMed Central ID: PMC8786667]. https://doi.org/10.1016/S2352-4642(21)00311-4.