Original Article

Epidemiologic View and Spatial Analysis of the Mortality of Children under 5 Years of Age in Isfahan Province in 2011–2016

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Abstract

Background: Children's mortality rate reflects the health level of the community. Therefore, accurate mapping of child mortality is one of the most important ways to reduce this rate. The purpose of this study was to investigate the mortality rate of children under 5 in Isfahan province in 2011–2016. **Methods:** In this analytical cross-sectional study, all mortalities of children under 5 of Isfahan province related to Child Death Care System Program during 2011–2016 were studied. Mortality rate of children was calculated. Relationship between variables [demographic characteristics, place of death (urban/rural), and underlying cause of death] and child mortality was analyzed using Chi-square test. Mortality rate in the cities of Isfahan province was plotted on a geographical map. **Results:** Whole number of mortalities of children under 5 was 5247 cases. Most of the mortalities (60.1%) were occurred in neonatal. Mortality rate was higher in boys than girls (12.6 vs. 11.1 per 1000 live births) ($P < 0.001$); "mortality rate in non-Iranians who live in Iran was more than that of Iranians (21.4 vs. 11.5 per 1000 live birth) ($P < 0.001$) and rural areas more than urban areas (15.2 vs. 11.4 per thousand live births) ($P < 0.001$)." Certain conditions originating in the perinatal period were reported as the greatest causes of death (45.9%). Congenital malformations (27.4%) and external causes of morbidity and mortality (6.7%) were the second and third causes of death. Fereidun Shahr had the highest U5MR and Khansar had the lowest U5MR. **Conclusions:** Considering the major contribution of neonatal to the death of children under 5 and also the most important causes of death, interventions such as preventing early delivery, genetic counseling in high-risk couples, and parent training for accident prevention can play an effective role in reducing child mortality.

Keywords: *Cause of death, child, epidemiology, Iran, mortality, spatial analysis*

Introduction

Mortality of children under 5 is a key indicator of socioeconomic development and reflects the health condition of the most vulnerable persons of society.[1] In 2000, world leaders in the Millennium Development Goals (MDG) called for a two-thirds reduction in the mortality of children under 5 in 1990–2015.[2]

Under 5 mortality rate (U5MR), by definition, is equal to the number of deaths of children under 5 per 1000 live births.[3] In 2015, the U5MR was significantly reduced across the world (53%), but goals of Millennium 4 Development to reduce the death of children to two-thirds since 1990 until 2015 were not realized.[4]

Factors such as strengthening the health system, policymakers' commitments, and the establishment of MDG together with the potential impact of overall economic and social development have contributed to reducing the global death rate of children globally. Despite this decline, more efforts are still needed to improve the survival of the neonatal and children.[5,6]

In 2010, around the world, almost 21,000 children under 5 have died daily.[7] Furthermore, congenital anomalies are one of the leading causes of child mortality worldwide.[8]

Accidents are also a leading cause of death for children in rich countries.[9] Each year millions of children lose their lives due to preventable accidents.[10] In 2012, the aim of reducing U5MR to 20 or less by 2035 and ending preventable deaths of children under 5 years in all countries were proposed.[11,12]

In the study of Mohammadi *et al*., the U5MR in Iran in 1990, 2000, 2010, and 2015 was 63.6, 38.8, 24.9, and

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19.4, respectively. Therefore, Iran achieved the overall goal of the MDG, however, the mortality rate in five provinces (Isfahan, Kermanshah, Yazd, Fars, and South Khorasan) has not fallen to two-thirds by 2015.[13]

By reviewing of the spatial variation in the mortality of children under the age of 5 years, policymakers can target the rarest resources to reduce death and scientists can make hypotheses related to the factors creating the geographic patterns.[14]

Failure of Isfahan province in achieving MDG, significance of indicator U5MR and multiple causes contributing of it, and the lack of spatial analysis of child deaths so far in the province prompted researchers to conduct the present study about the necessity of studying the epidemiological view and spatial distribution of death of children under 5 in Isfahan province between 2011 and 2016 in order to plan toward eliminating the preventable mortality in children under the age of 5 years.

Methods

Study design and participants

This analytical cross-sectional study was conducted on children under 5 years in Isfahan. All mortalities of children in this province, in 4 age groups (neonatal, 0–28 days; infant, 0–11 months; Children 1–59 months; and children under-5, 0–59 months) related to Children Death Care System (5247 deaths), were studied by Census. U5MR is the number of deaths of children under 5 per 1000 live births. The main components of U5MR are neonatal mortality rate (NMR: number of neonatal deaths from birth to 28 days per 1000 live births), infant mortality rate (IMR: the number of deaths of children under 1 years), and 59–1 months mortality rate (Number of deaths of children aged 1 to 59 months in 1000 live births).

Data sources

Data were collected from the Children Death Care System.

In this system, the method for collecting data is that personnel employed at comprehensive urban and rural health Centers, health department, and public and private hospitals are obliged to inform the health center of province about the death of children under 5 in 24 h. Then, the questioning team complete the questionnaires of death information by reviewing medical records and interviewing parents.

Province committee investigating the deaths of children younger than 5 examines the causes of child deaths every 2 months. In order to ensure the complete registration of deaths, the Organization of Registration will be coordinated monthly.

In the present study, the death reports of children under 5 in 2011–2016 including demographic characteristics, age, sex, nationality (Iranian/non-Iranian), place of residency (urban/rural), place of death (hospital/home/on the way to transfer/the scene of the accident), city of residence (21 city of Isfahan province), the underlying cause of death and also all born in the Isfahan province between 2011 and 2016 were obtained from the provincial experts of mortality statistics located in the Department of Health in Isfahan province.

Data analysis

Illnesses resulting in death were classified according to ICD10 Classification. To analyze the data, software SPSS (Statistical Package for the Social Sciences) version 20, IBM company was used. In order to investigate the relationship between children's death with other variables (gender, nationality, place of residence, place of death, city location, and underlying cause of death) Chi-square test (taking into account the significance level of 5%) was used.

Concerning the underlying cause of death, proportionate mortality (number of deaths from a particular disease to total deaths from all causes in the same year) was calculated in 4 age groups and the highest and lowest cause of death were studied in age groups.

Geographic analysis was also performed. Geographic analysis shows the spatial distribution of variables. At first, mortality rate was calculated in four age groups in Isfahan province cities. Then, the geographic map of Isfahan province was obtained from the Planning and Budgeting Organization. Mortality rates were shown on the geographic map, by using the software Arc GIS version 10.3. Due to the mortality rate of children in the whole of Isfahan province, the mortality rate in cities, in four floors, was shown from green to red.

Due to the confidentiality of the names of the deceased persons and the hospitals, ethical considerations were observed in the research, and beyond that, there was no other ethical problem in the study. (Study ethical approval number: 397271)

Results

In this study, the death information of all children under 5 years old in Isfahan province in 2011–2016 (5247 deaths) was reviewed [Table 1].

In general, mortality rates in all 4 age groups (neonatal, infant, children aged 1 to 59 months, and children under 5 years) in 2011 to 2016 were decreasing. Except for 2014 and 2016 when we faced increasing rates of death.

Dividing the death of children under 5 years into two groups of neonatal and 1–59 months, the most deaths have occurred in neonatal (60.1% vs. 39.9%) and at a different glance, 84.4% deaths have occurred in infants.

In studying the U5MR in terms of sex, nationality, and place of residence, the rates showed "increased mortality

in boys compared to girls," "non-Iranians who live in Iran compared to Iranians," and "rural compared to urban areas" [Tables 2 and 3].

The mortality rate of children was studied in terms of place of death. The highest mortality rates were in the hospital (10.3 per thousand live births) and then at home (1.1 per thousand live births), respectively.

In Chi-square analysis, which was performed for the comparison of deaths by gender, nationality, place of residence and place of death during 2011–2016, the proportion of death in the groups of nationality, place of residence, and place of death had a significant difference in all the studied years and the proportion of death in groups of sex also had significant difference at least 1 age group [Tables 2 and 3].

The average age of death in neonatal, infant, 59–1 months, and under 5 years was 5.97 ± 7.02 days, 1.4 ± 2.51 months, 14.47 ± 15.09 months, and 5.87 ± 11.8 months, respectively.

In the infants and neonatal, the highest cause of death was related to special conditions with prenatal origin and then

Table 1: Mortality rate of neonatal, infant, children aged 1 to 59 months and children under 5 years old in Isfahan province in 2011-2016

Year	Neonatal		Infant		1-59 months		Under 5 years		Be born
	Number	*Mortality rate	Number	*Mortality rate	Number	*Mortality rate	Number	*Mortality rate	
2011	549	7.9	797	11.5	388	5.6	937	13.5	69329
2012	512	7.2	696	9.8	343	4.8	855	12	71000
2013	502	7	694	9.6	309	4.3	811	11.2	72129
2014	527	7	751	9.9	356	4.7	883	11.7	75693
2015	498	6.7	709	9.5	331	4.4	829	11.1	74715
2016	566	7.3	784	10.2	366	4.7	932	12.1	77079
Total	3,154	7.2	4431	10.1	2093	4.8	5247	11.9	439945
Percentage of death	60.1		84.4		39.9		100		

*The mortality rate per 1,000 live births

Table 2: Distribution of death of neonatal, infant, children aged 1 to 59 months and children under 5 years in terms of sex and nationality in Isfahan in 2011-2016

Year	Sex	Be born	Neonatal			Infant			Under 5 years		
			Death number	*Mortality rate	*P*	Death number	*Mortality rate	*P*	Death number	*Mortality rate	*P*
2011	Boy	35,725	304	8.5	<0.001	435	12.2	<0.001	520	14.6	<0.001
	Girl	33,604	243	7.2		360	10.7		415	12.3	
	Iranian	67,878	527	7.8	<0.001	756	11.1	<0.001	893	13.2	<0.001
	Non Iranian	1,451	17	11.7		36	24.8		38	26.2	
2012	Boy	36,586	285	7.8	0.005	371	10.1	0.052	461	12.6	0.014
	Girl	34,414	222	6.5		320	9.3		389	11.3	
	Iranian	69,275	492	7.1	<0.001	662	9.6	<0.001	813	11.7	<0.001
	Non Iranian	1,725	18	10.4		31	18.0		39	22.6	
2013	Boy	37,168	269	7.2	0.089	372	10.0	0.048	439	11.8	0.015
	Girl	34,961	231	6.6		320	9.2		370	10.6	
	Iranian	70,379	475	6.7	<0.001	655	9.3	<0.001	767	10.9	<0.001
	Non Iranian	1,750	23	13.1		33	18.9		38	21.7	
2014	Boy	39,005	277	7.1	0.240	398	10.2	0.093	480	12.3	0.009
	Girl	36,688	250	6.8		352	9.6		402	11.0	
	Iranian	73,281	496	6.8	<0.001	707	9.6	<0.001	830	11.3	<0.001
	Non Iranian	2,412	31	12.9		44	18.2		53	22.0	
2015	Boy	38,501	271	7.0	<0.001	387	10.1	<0.001	464	12.1	<0.001
	Girl	36,214	226	6.2		321	8.9		364	10.1	
	Iranian	72,229	453	6.3	<0.001	647	9.0	<0.001	757	10.5	<0.001
	Non Iranian	2,486	38	15.3		55	22.1		65	26.1	
2016	Boy	39,719	315	7.9	0.005	430	10.8	0.005	504	12.7	0.011
	Girl	37,360	249	6.7		352	9.4		426	11.4	
	Iranian	72,416	517	7.1	<0.001	709	9.8	<0.001	848	11.7	<0.001
	Non Iranian	4,663	46	9.9		69	14.8		77	16.5	

*The mortality rate per 1,000 live births, in terms of gender and nationality

congenital anomalies. In children 1–9 months, due to passage from the critical period of the neonatal, congenital anomalies and external causes of morbidity and mortality (with priority of accidents) were the major causes of death.

In children under 5 years, special conditions with prenatal origin, congenital anomalies, and external causes of morbidity and mortality in all the studied years were the first to the third causes of death, respectively [Table 4].

Table 3: Distribution of death of neonatal, infant, children aged 1 to 59 months and children under 5 years in terms of place of residency in Isfahan in 2011-2016

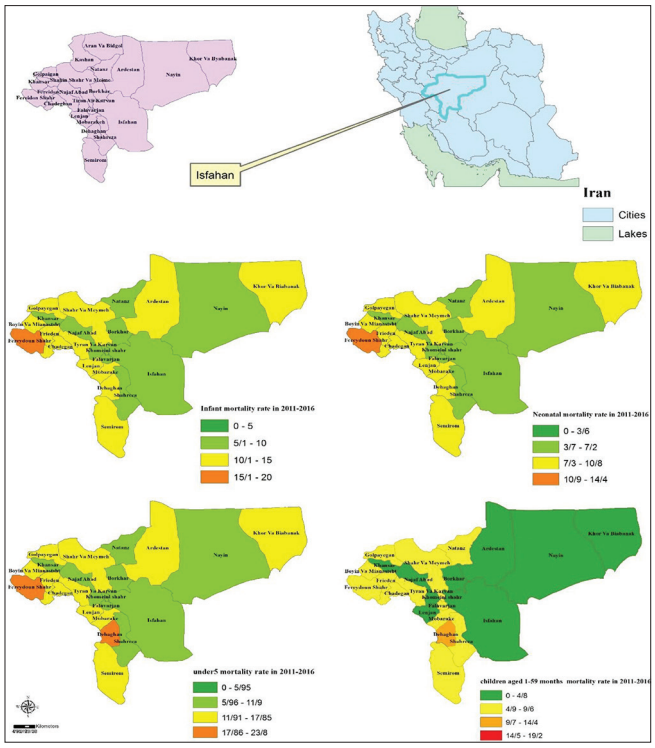
Year	Place of residence	Be born	Neonatal			Infant			Under 5 years		
			Death number	*Mortality rate	*P*	Death number	*Mortality rate	*P*	Death number	*Mortality rate	*P*
2011	Urban	59,746	458	7.7	<0.001	651	10.9	<0.001	760	12.7	<0.001
	rural	9,583	91	9.5		146	15.2		177	18.5	
2012	Urban	60,847	422	6.9	<0.001	591	9.7	<0.001	718	11.8	<0.001
	rural	10,153	89	8.8		104	10.2		136	13.4	
2013	Urban	62,907	422	6.7	<0.001	580	9.2	<0.001	674	10.7	<0.001
	rural	9,222	77	8.3		110	11.9		133	14.4	
2014	Urban	66,166	444	6.7	<0.001	635	9.6	<0.001	749	11.3	<0.001
	rural	9,527	83	8.7		116	12.2		134	14.1	
2015	Urban	65,062	421	6.5	<0.001	590	9.1	<0.001	696	10.7	<0.001
	rural	9,653	77	8.0		118	12.2		132	13.7	
2016	Urban	67,831	478	7.0	<0.001	649	9.6	<0.001	768	11.3	<0.001
	rural	9,248	87	9.4		133	14.4		161	17.4	

*The mortality rate per 1,000 live births in terms of place of residency

Table 4: Distribution of the underlying cause of death in neonatal, infant, children 1-59 months and children under 5 in Isfahan in 2011-2016

Underlying cause of death	Neonatal		Infant		1-59 months		Under 5	
	Number	proportionate mortality*	Number	proportionate mortality*	Number	proportionate mortality*	Number	proportionate mortality*
Certain infectious and parasitic diseases	7	0.2	84	1.9	112	5.3	119	2.3
Neoplasms	2	0.1	30	0.7	109	5.2	111	2.1
Diseases of the blood and blood-forming organs and immune system	1	0.0	45	1	64	3.1	65	1.2
Endocrine, nutritional, and metabolic diseases	57	1.8	151	3.4	128	6.1	185	3.5
Mental and behavioral disorders	0	0.0	1	0.0	9	0.4	9	0.2
Diseases of the nervous system	7	0.2	81	1.8	174	8.3	181	3.4
Diseases of the circulatory system	0	0.0	50	1.1	78	3.7	78	1.5
Diseases of the respiratory system	6	0.2	85	1.9	109	5.2	115	2.2
Diseases of the digestive system	0	0.0	56	1.3	81	3.9	81	1.5
Diseases of the skin and subcutaneous tissue	0	0.0	2	0.0	4	0.2	4	0.1
Diseases of the musculoskeletal system and connective tissue	0	0.0	1	0.0	3	0.1	3	0.1
Diseases of the genitourinary system	1	0.0	17	0.4	23	1.1	24	0.5
Certain conditions originating in the perinatal period	2303	73	2394	54	104	5	2407	45.9
Congenital malformations, deformations, and chromosomal abnormalities	764	24.2	1256	28.4	674	32.2	1438	27.4
Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified	2	0.1	51	1.2	74	3.5	76	1.4
External causes of morbidity and mortality	4	0.1	126	2.8	348	16.6	351	6.7
Total death number	3154	100	4430	100	2094	100	5247	100

*Proportionate mortality=Death of one cause/total deaths ×100



Map 1: The geographical distribution of mortality rate in neonatal, infant, children aged 1 to 59 months and children under 5 years in Isfahan Province during 2011–2016. *The mortality rate per 1,000 live births

To determine the distribution of children's mortality in 4 age groups, mortality rates were calculated in terms of age group and plotted on the geographical map.

Fereidounshahr city in neonatal, infant, and under 5 years and Dehaghan city in 1–59 months had the highest mortality rate. In Fereidounshahr, Dehaghan, Shahinshahr, Golpayegan, Boyin and Miandasht, Semirom, Mobarak, Tiran and Kron, Chadegan and Frieden, the mortality rate was higher in all age groups than in the Isfahan province [Map 1].

Discussion

Child mortality is caused by several factors that the strength, weakness and interactions of these factors determine the mortality rate.[15] Given the taken measures, the number of deaths under 5 years has declined 52% worldwide in 1990–2015,[16] in this study and other studies, the decreasing trend in mortality of children and neonatal has been observed.[5,13,17,18]

In the present study and in most studies,[3,5,17,19,20] boys have higher mortality rates than girls due to differences in their genetic and biological structure.[21] According to He *et al*. study, there are large disparities in child mortality in urban and rural areas.[22] In our study, as in some other studies, the frequency of death in rural areas is greater.[23,24] In the study of Lee *et al*. in Vietnam and Izadi *et al*. in Iran, the mortality rate was higher than in urban areas. The reason for this contradiction can be explained by the differences in the population structure of Iran and Vietnam and the differences in the time of studies. In the Izadi *et al*. study, the entire population was not studied and only hospital deaths were studied.[17,19]

According to the present study, most deaths occurred in neonatal and infant, which is inconsistent with the study by Tesfaye *et al*. in Ethiopia (children aged 3 to 4 had the highest number of deaths).[25] But in most studies all over the world, infants and neonatal have the highest percentage of death.[19,26,27] This reflects the fact that, despite all health and therapeutic interventions, infants and neonatal are still the most vulnerable age group.[15]

In the present study, the most important cause of death in infant and children under 5 years was determined as specific condition with prenatal origin followed by congenital malformation.

In the study by William *et al*. in United States, two-thirds of the deaths of infant were related to children who were born prematurely.[28] In the book by Kliegman *et al*. (edition 20, Year of publication 2015), prematurity followed by congenital abnormalities was considered as the most important cause of death in infant.[27]

In this study and in the study of Tajedini *et al*. and Safari *et al*., congenital malformations and external causes of mortality (accidents) were the most causes of death in children 1–59 months.[29,30]

In the study of Izadi *et al*. and Shahraki *et al*., accidents were the leading cause of death in children 1–59 months and in studies done in South Africa and China, the main cause of the death of children 1–4 years was reported as accidents.[19,20,31,32] Soori *et al*. also considered accidents, congenital anomalies, and premature birth as the causes of higher death rate of Iranian children than the global average.[33]

The above points reflect the fact that not only accidents are one of the important causes of death, but it is completely preventable and should be intervened to reduce it.

Strengths and limitations

Complete registration of deaths of children under the age of 5 years and population-based data from the covered area of Isfahan University of Medical is considered as the strength of this study. Lack of information such as parental education and socioeconomic and cultural status of families in Children Death Care System program are some of the limitations of the present study. It is suggested that researchers map the mortality rate of children in urban and rural areas and access to health care on a geographic map. Especially in neonates who have died of premature birth, the distance to NICU hospitals.

Conclusion

Considering the fact that the highest number of deaths was in the neonatal, so the mortality rate of children under

5 years was most affected by the largest cause of death in neonatal and infant (special conditions with prenatal origin, especially prematurity and congenital anomalies).

Therefore, by intervention to reduce neonatal death (preventing preterm labor and controlling congenital malformations), great achievements can be made to reduce the deaths of children under the age of 5 years. About 1–59 months deaths, with regarding the importance of accidents (the third cause of death of under 5 years and the second cause of death of 1–59 months) and its preventability, it can help reduce these deaths by intervention programs.

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Conflicts of interest

There are no conflicts of interest.

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