Original Article

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Trends in the Causes of Maternal Mortality in Iran and other Countries in the Region During the Years 1990 – 2016

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ABSTRACT

BACKGROUND AND OBJECTIVE: Understanding the causes and frequency of maternal mortality and their occurrence over time is the first important step in policymaking to reduce maternal mortality. The purpose of this study was to compare the trends in the causes of maternal mortality in Iran and other countries in the region including 30 countries.

METHODS: In this longitudinal, retrospective cohort study, the trends in causes of maternal mortality between 1990 and 2016 were evaluated. The study data were collected from the Global Burden of Disease Study (GBD) website and a secondary analysis was performed using Multilevel Linear Regression Models. In this study, "time" is the independent variable and "percentage of causes of death" is the dependent variable.

FINDINGS: Among the direct causes of death, hemorrhage, despite a significant decreasing trend, was the most important cause of maternal mortality in Iran with a coefficient of 0.28 (CI = -0.25, -0.31, $p<0.001$). Other direct causes of death, including hypertension, infection, abortion and ectopic pregnancy, labor obstruction, and uterine rupture and death due to delays, all showed a significant decreasing trend during the annual period with regression coefficients of 0.17, 0.16, 0.15, 0.13, and 0.02, respectively ($p<0.001$). After hemorrhage, indirect causes and deaths due to other reasons were respectively ranked as second and third causes. The trends in almost all causes of death in Iran have declined significantly over this period compared to other countries in the region.

CONCLUSION: The results of the study showed that the trends in all causes of maternal mortality has decreased significantly in Iran over the past 26 years, but this decline was lower compared to other countries in the region.

KEY WORDS: *Maternal Mortality, Causes of Death, Trend, Iran, Countries of the Region, Longitudinal Study.*

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Introduction

The World Health Organization defines maternal mortality as the death of women during pregnancy, during labor, or within 42 days after childbirth, either directly or indirectly (1). In addition, death that occurs after 42 days until one year after labor is known as late maternal death (1), but the first definition is used in this study. More than 800 maternal deaths occur every day in the world, of which over 99% are in developing countries (2, 3). The rate of maternal death, which is called the Maternal Mortality Rate (MMR), includes the number of maternal deaths per 100,000 live births, and is the most important indicator of maternal mortality in a country. Not only is it an important index to measure the mortality status of a society, it also reflects the quality of the health care system and the role and importance of women in that society (4).

According to global statistics, maternal mortality rate has decreased from 385 in 1990 to 216 in 2015 (2). Although this figure has been declining over this period, many countries in the world have failed to achieve the Millennium Development Goal (MDG) 5, which was related to maternal health and included 75% reduction in maternal mortality from 1990 to 2015 (5). In Iran, according to national data, this rate was 25 deaths per 100,000 live births in 2015, which was an 80% decline over the past 26 years and was among the countries that gained experience in achieving the Millennium Development Goal (1).

However, this mortality rate showed a significant difference during this period compared to some countries in the region, such as Kuwait, Qatar and Oman, as well as advanced and high-income countries, whose mortality rate decreased from 18 deaths per 100,000 live births in 1990 to 13 deaths in 2015. Even in many European countries, including Denmark, the Czech Republic and Greece, maternal mortality rates have been single-digit since the past two decades, which is a much better condition compared to Iran (1, 6). Therefore, understanding the causes of maternal mortality and their prevalence in Iran, especially considering the trends of each cause over time, can provide valuable information to health policymakers in the country to enable effective and scientific interventions to reduce maternal mortality according to their causes and frequency.

According to the International Classification of Diseases (ICD-10), the causes of maternal mortality are divided into two categories: direct and indirect. Direct causes are categorized into six groups, including hemorrhage, infection, hypertension, miscarriage, unexpected management complications (such as medical errors) and other complications related to childbirth. Indirect causes also vary widely, most notably cardiac, nervous, respiratory, and gastrointestinal diseases, cancers, and other non-delivery complications that are exacerbated by pregnancy (7).

According to the results of the study by Say et al., which was performed based on the same classification across the world and based on regions of the world, hemorrhage was the most important direct cause, while indirect causes with the second highest frequency respectively caused 27 and 28% of maternal deaths in the world between 2003 and 2009 (8). According to the same study, most deaths occurred in developing countries, and the maternal mortality rates in developing areas were 166 times higher than developed countries. However, in both developing and developed countries, indirect causes and hemorrhage were among the most important causes of maternal death (8).

Many studies have been conducted in Iran to identify the causes of maternal deaths, but most of these studies were not conducted at national level (9, 10) or their national-level evidence (11) investigated the causes for only a few years and they lack the value of time or they were review articles (12, 13). The findings of two systematic reviews in Iran (12, 13), both conducted in the last year, showed that approximately 70% of maternal deaths in Iran were due to direct causes and the rest were due to indirect causes or unknow causes. These studies also confirmed that more than 30% of deaths were due to hemorrhage, about 17% due to hypertension and 8% due to heart disease (13). Therefore, it was necessary to conduct a preliminary study at national level over a long period. Longitudinal studies, rather than studies based only on one point of time, can evaluate the trend of causes of death over the past years, given the financial and economic crises, widespread environmental, social, and political changes in our country in recent years. It can also provide more valuable evidence and provide better predictive power for policymakers (14). Since comparative studies, especially longitudinal studies, provide valuable information for making scientific assumptions for future studies, this study was conducted to investigate the trends in the causes of maternal mortality in Iran over the past 27 years (considering data availability), and to compare each of the causes of death in Iran with other countries in the region over the same time period.

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Methods

This is a longitudinal or historic cohort study that retrospectively investigates the causes of maternal mortality in Iran and other countries in the region during 1990 – 2016. The unit of analysis for this study is the country, and measurements within each country are repeated over time and annually. This study was approved by the Ethics Committee of Tehran University of Medical Sciences with the code of ethics IR.TUMS.SPH.REC.1397.4975.

Data related to causes of death were collected by visiting the Global Burden of Disease (GBD) website, which is owned by the Institute for Health Metrics and Evaluation (IHME) (15). According to the categorization on this site, the causes of maternal death are generally classified into 9 categories including hemorrhage, infections (maternal sepsis and other infections), hypertensive disorders, abortion, miscarriage, and ectopic pregnancy, maternal obstructed labor and uterine rupture, late maternal deaths, maternal deaths aggravated by HIV/AIDS, indirect causes and other causes.

In order to compare the causes of death in Iran with other countries in the region, different categorizations that have been used across countries around the world were also used here as far as possible, so that Iran was included among the countries of these regions. Thus, we included member states of UNICEF in the Middle East and North Africa (MENA) and the World Bank in this region, the countries of the Eastern Mediterranean region of the World Health Organization, as well as the countries of the South Asia such as Iran that are the target of the United Nations Millennium Development Goals, which was also categorized in one study (12). Overall, the causes of maternal deaths in Iran were compared with 30 countries in the region, including Afghanistan, Bahrain, Pakistan, Somalia, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, the United Arab Emirates The United Arab Emirates, Yemen, Algeria, Palestine, Malta, Israel, Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka.

Given the necessity of considering time factor in all analyses, linear regression analysis was used to describe or explain the trends in causes of death based on time. In fact, this analysis was used to measure the slope of changes in mortality rates for each country, where "time" is the independent variable and "percentage of causes of death" is the dependent variable. In addition, considering the importance of the effect of time and investigation of causes in more than one place, mixed-effect multilevel regression analysis (16) was used to determine the difference in regression coefficient of each cause of death in Iran compared to other countries in the region; the first level is the measurement of a variable at a particular time and the second level is the country in which these measurements were done. In this study, data were first entered into Microsoft Excel 2013 (Microsoft Crop., Redmond, WA, USA). Then, all regression analyses were performed using Stata version 14 (Stata Corp., College Station, Texas) and $p < 0.05$ was considered significant.

Results

According to Figure 1, based on estimates of the Global Burden of Disease (GBD), maternal mortality in Iran has decreased from about 40 deaths per 100,000 live births in 1990 to 14 deaths in 2016 (Fig 1). Accordingly, the results of statistical analyses show that the annual rate of death decreased by 1.36 units over this period, which is also statistically significant (CI= -1.2, -1.5, $p<0.001$). According to this Figure, the death rate for the first seven years (from 1990 to 1996) had a rising trend by five deaths per year, reaching a peak of 45 deaths in 1996, then had a falling trend from this point in time, and reached the lowest level in 2016, which is 14 deaths per 100,000 live births.

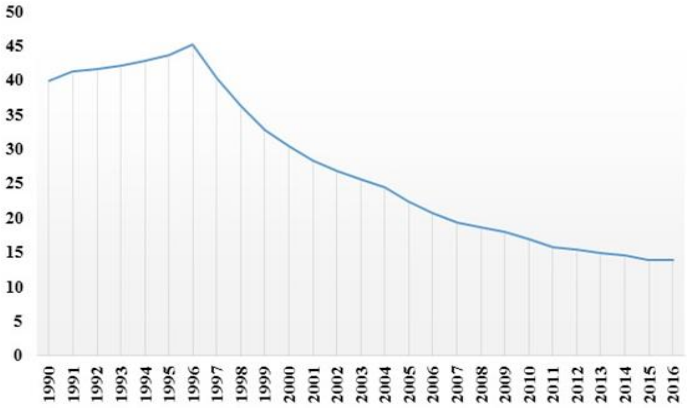

Figure 1. Trend of maternal mortality rate in Iran during 1990 – 2016 based on Global Burden of Disease data

The most common cause of maternal deaths during the period was hemorrhage, and maternal mortality rates due to hemorrhage decreased from 8 in 1990 to 3 in 2016 (Fig 2). Maternal mortality due to hemorrhage had an increasing trend in seven years, reaching a peak of 9.5 in 1996, and has declined since then. The results of statistical tests show that the average maternal mortality rate due to hemorrhage decreased by 0.28 units per year

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over the 27 years, which was statistically significant (p<0.001).

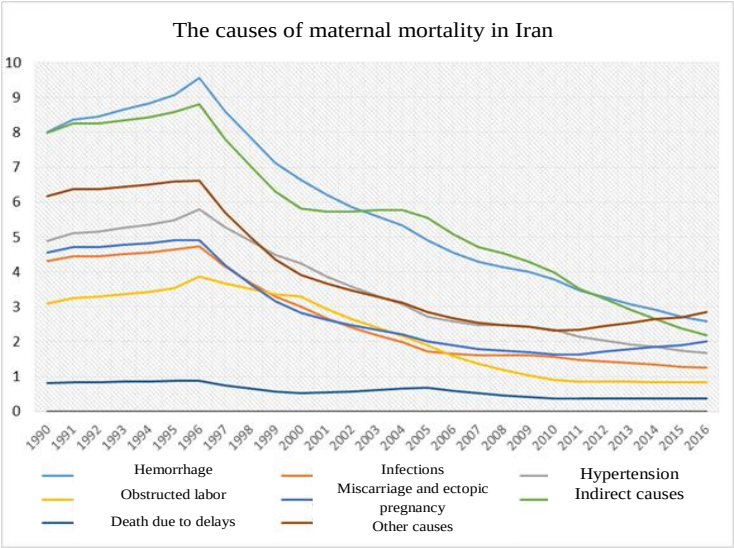

Figure 2. Trend in causes of maternal deaths in Iran from 1990 to 2016 based on Global Burden of Disease data

However, statistical comparisons of the findings of Iran with those of the region show that death due to hemorrhage during the study period in Iran decreased by 1.18 units per year less than other countries in the region (p=0.009) (Table 1). After hemorrhage, among other direct causes of maternal death in Iran, hypertension, infections, abortion and ectopic pregnancy, obstructed labor and uterine rupture and death due to delays all showed a significant decreasing trend during the annual period with regression coefficients of 0.17, 0.16, 0.15, 0.13, and 0.02, respectively (Table 1). Comparative findings of Iran and the region show that most of the direct causes of death, including hypertension, infections and deaths due to delays in Iran had slower falling trend than other countries in the region, and this difference is statistically significant in all these cases. In addition, mortality rates due to obstructed labor and uterine rupture in Iran had respectively faster rising trend and slower falling trend compared to other countries in the region, although these findings were not statistically significant.

Another important cause of maternal death in Iran is indirect death, which has been recognized as the most common cause of maternal death, even for several consecutive years (from 2003 to 2011). This group of causes first had a rising trend in seven years (1990–1996) and then has been decreasing in some years with some fluctuations, but generally the rate of maternal mortality due to indirect causes decreased significantly in Iran by 0.26 units per year (p<0.001); however, this decrease in Iran was 0.44 units lower compared to the countries of the region, which is statistically significant (p=0.029). The causes of death other than those mentioned above, which may include death due to management factors such as medical errors or unknown factors, etc., also had a significant decrease of 0.19 units per year in Iran during this period (p<0.001), and about 0.1 fewer deaths has occurred in Iran in comparison with other countries in the region and this difference is statistically significant (p=0.002).

Table 1. Results of multilevel regression model (regression coefficient) of changes in causes of maternal death in Iran and other countries in the region during the years 1990 to 2016 and the result of the statistical difference test regarding the rate of changes in Iran and other countries in the region during this period

Causes of maternal death	Rate of Changes in Causes of Death in Iran			Rate of changes in causes of death in other countries in the region			Statistical difference of rate of changes in causes of death in Iran and other countries in the region		
	Coef	CI	P-value	Coef	CI	P-value	Coef	CI	P-value
Haemorrhage	- 0.28	- 0.25, - 0.31	< 0.001	- 1.46	- 0.80, - 2.11	< 0.001	1.18	2.07, 0.29	0.009
Hypertension	- 0.17	- 0.15, - 0.19	< 0.001	- 0.53	- 0.26, - 0.80	< 0.001	0.36	0.65, 0.06	0.018
Abortion and ectopic pregnancies	- 0.15	- 0.12, - 0.17	< 0.001	- 0.21	- 0.10, - 0.32	< 0.001	0.07	0.36, - 0.23	0.654
Death due to delays	- 0.02	- 0.02, - 0.03	< 0.001	- 0.12	- 0.07, - 0.17	< 0.001	0.10	0.18, 0.02	0.017
Infections	- 0.16	- 0.18, - 0.13	< 0.001	- 0.50	- 0.27, - 0.73	< 0.001	0.34	0.57, 0.11	0.004
Obstructed labor and uterine rupture	- 0.13	- 0.11, - 0.16	< 0.001	- 0.10	0.04, - 0.24	0.149	- 0.03	0.05, - 0.11	0.458
Indirect causes	- 0.26	- 0.24, - 0.28	< 0.001	- 0.70	- 0.25, - 1.15	0.002	0.44	0.84, 0.04	0.029
Other causes	- 0.19	- 0.16, - 0.23	< 0.001	- 1.13	- 0.78, - 1.48	< 0.001	0.94	1.55, 0.33	0.002

CI: Confidence Interval, Coef: Regression Coefficient

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Discussion

According to the analysis carried out in this study using data from the GBD website, the maternal death rate (MMR) in Iran has decreased from about 40 deaths per 100,000 live births in 1990 to 14 deaths in 2016, and on average, Iran experienced a 1.36 units reduction in deaths per year. However, according to the data of Ministry of Health, which is consistent with reports of maternal deaths from different parts of the country and is also shown on the World Health Organization website (17, 18), the MMR in Iran has been consistently decreasing over the whole period without having a peak during the first years, and decreased from 123 deaths in 1990 to 25 deaths in 2015, which is an average of 3.7 units per year (19) (Fig 3).

Evidence suggests that genuine national data are more reliable than GBD data, and the observed contradiction is largely due to the fact that GBD data are mostly based on estimations and they consider the conditions of other countries close to Iran when estimating the data. Of course, this contradiction also applies to most countries in the region, and there is a statistically significant difference in maternal mortality rates between the World Health Organization website and the GBD website (17, 18).

Furthermore, the findings of this study showed that hemorrhage and indirect factors have been the most common causes of maternal deaths in Iran and in the region during the past years. This finding is consistent with the results of the most recent systematic reviews in Iran (12, 13); according to the findings of Zalvand et al., hemorrhage with about 31% and indirect factors with 21% frequency are the most common causes of maternal death in the country (13). A systematic review was conducted by Say et al. at global level between 2003 – 2009 and across different regions of the world. In this study, in the West and South Asian regions, which includes most of the countries studied in this article, hemorrhage with an incidence of 30% as well as death due to indirect causes are the most important causes of maternal death (8).

The findings comparing Iran with the countries of the region in this study indicate that hemorrhage and indirect causes in Iran decreased 1.18 and 0.44 units per year lower than other countries of the region, respectively. Perhaps the most important reason for the further decline in maternal mortality in other countries in the region compared to Iran is because most of these countries, such as Afghanistan, Somalia, Bhutan, and several other countries, had very high MMR. As a result, because of the importance of the issue of maternal mortality, they have received special attention from international organizations such as the World Health Organization and have thus experienced a further decline, although they still have more significant rates of death compared to Iran. However, these findings confirm the importance of paying attention to the issue of hemorrhage in mothers, and further studies are required to identify the exact dimensions of this issue, hemorrhage factors, hemorrhage leading to death and interventions needed to control this problem, and to assess the effectiveness of ongoing interventions (20).

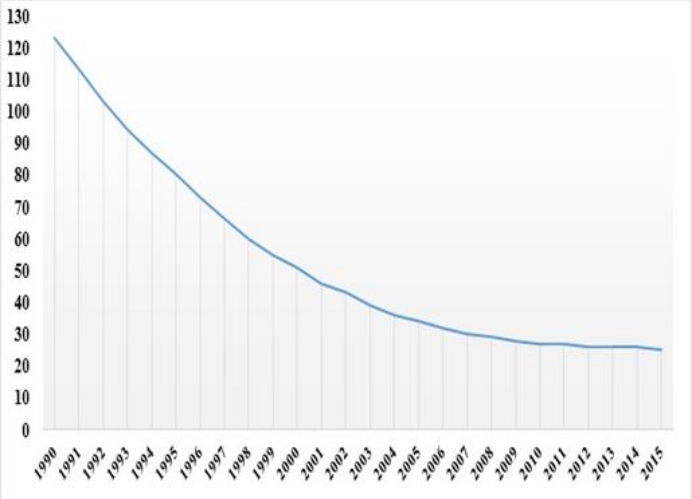

Figure 3. Trends in maternal mortality rate in Iran during 1990 – 2015 based on national data and World Health Organization website (13)

Furthermore, according to the findings of this study, hypertension, miscarriage and ectopic pregnancy and infections are respectively the other leading causes of maternal mortality in Iran; hypertension, miscarriage and ectopic pregnancy were each responsible for 2 units of MMR and infections were responsible for 1 unit of MMR in Iran in 2016. The result of the comparative analysis shows that Iran had 0.3 unit lower annual death rate due to hypertension and infections (each alone) compared to other countries in the region almost every year. However, this does not mean that the situation in Iran is worse than other countries in the region, because according to GBD website, there were respectively around 16 and 13 units of MMR in the region due to hypertension and infection in 2016, which is respectively 8 and 13 times more than Iran. In this regard, the results of the study by Dadipoor et al. in Iran show that hypertension and infections are the most frequent causes of death after hemorrhage (12). Moreover, the results of the study by Vahiddastjerdy et al. between 2009 and 2012 in Iran shows that

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miscarriage is responsible for more than 3% of deaths (20). The results of other studies in the region and the world consider these three causes as the most important direct causes after hemorrhage (3, 8, 21). These findings emphasize the importance of adequate and high-quality prenatal care for early detection and control of hypertension, as well as prevention of infections and appropriate treatment in pregnant mothers, which may themselves be the cause of miscarriage (12).

The results of this study, considering the data of about 3 decades in the country and comparing it with the countries in the region during this period, are of particular importance for cross-sectional or short-term studies and can be useful for health policymakers in predicting the causes of maternal death in Iran in the future. Furthermore, the findings of this study are very reliable due to the use of sophisticated and complex statistical analysis and can provide a field for further studies.

However, this study also has some limitations, the most important of which is the estimation of Global Burden of Disease (GBD) data, which is the basis of the analysis in this study. Since the data about the causes of death are nowhere else to be found, and they are not complete and accurate even at the level of Ministry of Health of countries, and they are highly confidential and will not be available to researchers, the only way is using estimated data from international sources. However, given the comparative evaluation of the causes in different countries, it is possible that the error in estimating the data may be a systematic error and not very effective. The results of the study showed that all causes of death in Iran decreased significantly during the study period but decreased less than other countries. Considering the results regarding the causes of maternal deaths in Iran within about three decades and comparing it with other countries in the region and elsewhere in the world, important conclusions can be obtained and as a result, plans and policies can be designed or improved to reduce maternal mortality rates in Iran considering the important causes of death or the causes with a rising trend.

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