Geographic Distribution of Excess Mortality Rate Duo to COVID-19 in Iranian Population: An Ecological Study

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Title:

Geographic Distribution of Excess Mortality Rate due to COVID-19 in Iranian Population: An Ecological Study

Running Title: COVID-19 Mortality Rate

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Abstract

Introduction: COVID-19 has raised world concern since it emerged in Wuhan, China in December 2019. The direct and indirect death rates in the world and in Iran have increased significantly after the occurrence of this pandemic in the world.

Objective: In this study EMR estimated by Multilevel Poisson Regression then this estimation compared to the historical trends, to obtain total death related to the COVID-19 in addition the geographic distribution of EMR has been presented for Iran country.

Materials and Methods: All-cause mortality count of each province of Iran from March 21, 2013 to June 20, 2020 downloaded from National Organization for Civil Registration (NOCR). The data from spring of 2020 (March 20, 2020 to June 20, 2020) remove from data and then the multilevel poisson model has been used to estimate all-cause mortality in spring 2020 then excess mortality attributable to COVID-19 (the difference between the number of registered and expected deaths) has been calculated.

Results: The results of this study showed that Iran's EMR in spring 2020 was 23% (Male=25%, Female=21%). More result also showed that four category low ($EMR \leq 5\%$, $n=3$), moderate ($5\% < EMR < 20\%$, $n=10$), high ($20\% < EMR < 40\%$, $n=16$) and very high ($40 \leq EMR$, $n=2$) EMR.

Conclusion: Due to the diverse EMR in different provinces of Iran, the type of management of provinces with low and moderate EMR can be used as a suitable model to control EMR in provinces with high and very high EMR.

Keywords: COVID-19, SARS-CoV-2, Coronavirus, Iran, Mortality, Excess mortality, Excess deaths

Introduction:

In late 2019 began a wave of respiratory diseases in Wuhan(China) On March 11, 2020, according to the World Health Organization, the COVID-19 pandemic was announced(1). The virus has been around since December 31, 2019 to December 01, 2020 around the world 62 363 527 Infected people and to this day leads to the death of more than 1 456 687 It has spread all over the world(2).

The number of confirmed cases of COVID-19 in each country depends on the actual number of cases, the capacity of the health system to identify cases and its transparency in reporting the correct steps. The health system's capacity to diagnose cases is powered by multiple factors. Factors such as the affordability and accessibility of healthcare facilities and diagnostic and screening) tests, the accuracy of laboratory tests, and public awareness raising illness, and the development of a mechanism for finding care (3-5) . The number of cases confirmed does not, therefore, actually reflect the actual number of cases (3). In fact, for various reasons such as the small number of diagnostic laboratories, lack of access to appropriate diagnostic kits, lack of access to health services due to excessive visits to medical centers, high cost and low sensitivity of COVID-19 diagnostic tests of many people due to disease COVID-19 have not necessarily been reported by the Ministry of Health and Medical Education (MoHME) as a statistic due to COVID-19(3, 6) thus, estimating Excess Mortality Rate (EMR) for all reasons from the National Organization for Civil Registration (NOCR)(7)(25) can be used to accurate estimation of COVID-19 death .This accurate estimation will allow health managers to handle this epidemic better and properly.

Objective:

In this study EMR estimated by Multilevel Poisson Regression then this estimation compared to the historical trends, to obtain total death related to the COVID-19 in addition the geographic distribution of EMR has been presented for Iran country.

Materials and Methods

This study is a longitudinal ecological study. All-cause mortality count of each province of Iran from March 21, 2013 to June 20, 2020 downloaded from Iranian National Organization for Civil Registration (INOCR). The data from spring of 2020 (March 20, 2020 to June 20, 2020) remove

from data and then the multilevel poisson model has been used to estimate all-cause mortality in spring 2020 then excess mortality attributable to COVID-19 (the difference between the number of registered and expected deaths) has been calculated. In other hand for comparison the statistics reported by MoHME, the statistics reported by Islamic Republic News Agency (IRNA.ir) has been used.

Data analysis

In this study multilevel poisson model has been used to predict number of all-cause mortality in spring 2020 if the COVID-19 not exists.

For this purpose, The Data about the death of each province of Iran in the time period (March 21, 2013 to June 20, 2020) has been downloaded from INOCR website (<https://www.sabteahval.ir>) then the multilevel poisson model (8) run and then the number of death has been estimated.

$$\text{Log}(\mu_{\text{Death}_{its}}) = \beta_0 + \beta_1(\text{Year}_{its} - 2012) + \text{Season}_{its} + \text{Gender}_{its} + \text{Province}_{its} + u_i$$

Where index i variate from 1 to 31 (number of provinces of Iran), index t from 1 to 8 (2013 to 2020) and index s from 1 to 4 (4 seasons spring, summer, autumn and winter). In the above model, u_i is a normal random effect to control the dependence between observations. In this study MLWiN software version 2.1 has been used. In the current study maps indicating the geographical distribution of the EMR prepared by <https://paintmaps.com/map-charts/105/Iran-map-chart>. The EMR calculated number of predicted death/number of real death.

Ethical Consideration

Ethical approval was not needed for the study, which is based on surveillance data only.

Results:

According to the statistics reported by the INOCR in the spring 2020, 109943 deaths have been reported. Of these, 62751 (57%) deaths were related to men and 47192 (43%) deaths were related to women. After fitting the multilevel poisson model ($R^2=99\%$), the model estimated 89341 death in absence of COVID-19 in spring 1399 SH (March 20, 2020 to June 20, 2020). According to the MoHME statistics 8223 deaths related to the COVID-19. This means that the deaths rate related to the COVID-19 is 2.5 times higher than the statistics announced by MoHME. Due to the lack of information by INOCR in summer 1399 SH (June 21, 2020 to

September 21, 2020) with using statistical models and MoHME report the real death calculated and final estimation has been reported in Figure1. The model predicted that finally 158322 deaths may be occurred to autumn 1399 SH (September 22, 2020 to December 20, 2020).

Figure1: The trend of real death and MoHME death report related to the COVID-19 in Iran country

In Table 1, the real and expected death and EMR according to the gender and province of Iran in spring 1399 SH (March 20, 2020 to June 20, 2020) has been reported. The results of this Tables showed that Iran's EMR in spring 2020 was 23% (Male=25%, Female=21%). More result also showed that four category low ($EMR \leq 5\%$, $n=3$, including province Sistan&Baluchestan, Fars, Chaharmahal&Bakhtiari), moderate ($5\% < EMR < 20\%$, $n=10$, including province Kerman, Hormozgan, Bushehr, Kohgiluyeh&BuyerAhmad, Kermanshah, Hamedan, Markazi, Razavi Khorasan, East and West Azarbaijan), high ($20\% < EMR < 40\%$, $n=16$, including province Yazd, South and North Khorasan, Esfahan, Khuzestan, Lorestan, Ilam, Qom, Tehran, Semnan, Mazandaran, Golestan, Gilan, Ardebil, Zanjan, Kordestan) and very high ($40 \leq EMR$, $n=2$, including province Qazvin and Alborz) EMR. in addition the GIS map for rate of EMR has been presented in Figure2.

Table 1: The real and expected death and EMR according to the gender and province of Iran in spring 1399 SH
(March 20, 2020 to June 20, 2020)

Province	Male			Female			Total		
	Real Death	Expected Death	EMR	Real Death	Expected Death	EMR	Real Death	Expected Death	EMR
East Azarbaijan	3694	2884	28%	2786	2526	10%	6480	5410	20%
West Azarbaijan	2337	1996	17%	1988	1637	21%	4325	3633	19%
Ardebil	1189	955	25%	910	596	53%	2099	1551	35%
Esfahan	3944	3025	30%	3112	2667	17%	7056	5692	24%
Alborz	1907	1311	45%	1440	953	51%	3347	2264	48%
Ilam	443	442	0%	244	83	194%	687	525	31%
Bushehr	572	642	-11%	455	283	61%	1027	925	11%
Tehran	10298	7062	46%	7312	6704	9%	17610	13766	28%
ChaharMahall&Bakhtiari	610	718	-15%	444	359	24%	1054	1077	-2%
South Khorasan	568	601	-5%	484	242	100%	1052	843	25%
Razavi Khorasan	4892	3858	27%	3768	3500	8%	8660	7358	18%
NorthKhorasan	692	688	1%	589	329	79%	1281	1017	26%
Khuzestan	3704	2635	41%	2678	2277	18%	6382	4912	30%
Zanjan	893	811	10%	689	452	52%	1582	1263	25%
Semnan	570	535	7%	406	176	131%	976	711	37%
Sistan&Baluchestan	1642	1733	-5%	1265	1374	-8%	2907	3107	-6%
Fars	3180	2850	12%	2336	2491	-6%	5516	5341	3%
Qazvin	1135	857	32%	929	498	87%	2064	1355	52%
Qom	1056	846	25%	763	487	57%	1819	1333	36%
Kordestan	1336	1070	25%	887	711	25%	2223	1781	25%
Kerman	1999	1729	16%	1472	1370	7%	3471	3099	12%
Kermanshah	1857	1499	24%	1270	1140	11%	3127	2639	18%
Kohgiluyeh&BuyerAhmad	448	494	-9%	304	135	125%	752	629	20%
Golestan	1576	1227	28%	1273	868	47%	2849	2095	36%
Gilan	2903	2180	33%	2351	1821	29%	5254	4001	31%
Lorestan	1547	1220	27%	1052	861	22%	2599	2081	25%
Mazandaran	2982	2163	38%	2450	1804	36%	5432	3967	37%
Markazi	1266	1116	13%	938	757	24%	2204	1873	18%
Hormozgan	1010	936	8%	670	578	16%	1680	1514	11%
Hamadan	1660	1436	16%	1277	1078	18%	2937	2514	17%
Yazd	841	712	18%	650	353	84%	1491	1065	40%
Total	62751	50231	25%	47192	39110	21%	109943	89341	23%

of this index, it can be calculated in all countries and provide an accurate estimate of the COVID-19 mortality.

The results of this study showed that Iran's EMR in spring 1399 SH (March 20, 2020 to June 20, 2020) was 23% (Male=25%, Female=21%). the EMR reported in this study is lower than EMR reported by Freitas et al (11) and Strang et al (12) study and upper than Michelozzi et al (13), Woolf et al (14), Weinberger et al (15) and Vieira et al (16) study. Strang et al (12) showed that 23% and 113% EMR in Sudan (March and April 2020) respectively. Freitas et al (11) reported 66% EMR in six Brazilian (COVID-19 period to May 2, 2020), Michelozzi et al (13) reported the 19% EMR in Italian cities (COVID-19 period starts on February 29th, 2020), Woolf et al (14) showed the 20.8% EMR in 50 US states and the District of Columbia (January through April 2020). Freitas et al (11) showed the 66% EMR in six Brazilian capitals (COVID-19 period to May 2, 2020), Weinberger et al (15) showed the 18.5% EMR in United States (March to May 2020), Vieira et al (16) showed the 15.8% EMR in Portugal (March to May 2020).

Further results of this study showed that Alborz and Qazvin provinces showed the highest EMR index compared to other provinces. This result can be justified by the fact that these two provinces are on the way to the Northern provinces, the main provinces for recreational purposes in Iran, especially from Tehran province, thus high EMR index is due to the way passengers travel. Previous studies has been identified that travel is a major risk factor for spread COVID-19(17-19).

More results showed that the provinces of the southern strip of Iran, which are generally non-industrial, have a lower EMR index than other provinces. The reason for this can be considered as air pollution and also the less connection of these provinces with Qom and Tehran provinces (first provinces that reported COVID-19 in Iran). Previous studies have reported a negative

association between Air Quality and COVID-19 death (20-22). Two limitations of this study were 1- not reporting information about death by INOCR and 2- Lack of reporting of COVID-19 death according to provinces by MoHME. in addition there are some strong points in this analysis that should be considered. 1-use of complex and powerful statistical methods in estimating the number of deaths and graphical presentaion of EMR by GIS method.

Conclusion:

Due to the diverse EMR in different provinces of Iran, the type of management of provinces with low and moderate EMR can be used as a suitable model to control EMR in provinces with high and very high EMR.

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Conflict of Interests:

Authors have no conflict of interests.

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Figures

Figure 1

The trend of real death and MoHME death report related to the COVID-19 in Iran country

Figure 2

The GIS map for rate of EMR Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.