MEDICINA UNIVERSITARIA

www.elsevier.es/rmuanl

ORIGINAL ARTICLE

Analysis of mortality during the winter seasons in Mexico from 2000 to 2012

Omar González-Santiago,* Isaías Balderas-Rentería, Evangelina Ramírez-Lara, and Sandra L. Gracia-Vásquez

Postgraduate Division, School of Chemical Sciences, Universidad Autónoma de Nuevo León, San Nicolás de los Garza, Nuevo León, México

Abstract
Objective: To analyze mortality from all causes in Mexico during the winter months.
Methods: Data was extracted and tabulated on monthly all-cause mortality in the general population from 2000 to 2012 from the INEGI database. Coefficients of seasonal variation in mortality were calculated.
Results: In Mexico there was an increase of 14 % in mortality in the general population during winter. The more susceptible age groups were older people and children, with increases of 18% and 13% respectively. The months with low levels of mortality were April, October and September for children, adolescents and older people respectively.
Conclusions: Important increases in winter mortality occur in Mexico.

Introduction

Seasonal variation in mortality has been widely studied around the world.[1-3] It has been noted that mortality peaks during winter, and most countries suffer an increase in deaths, going from 5% up to 30%, compared with summer.[4] Although winter is considered a difficult period, paradoxically the variation in mortality is low in intense winter areas like Russia, Norway and Canada.[5] It is possible that fluctuations in climatic conditions alone do not explain seasonal mortality, especially in winter. It is believed that human behavior patterns, socioeconomic factors and environmental parameters[6] are related to seasonal variation in mortality.

It is essential to understand the seasonality of this phenomenon, in order to establish rational policies concerning planning the demand of healthcare services during the different seasons, and to evaluate progress when the proper strategies are implemented. In this matter, in Mexico there is scarce information about the existence of an increase in mortality during winter and of its magnitude in case it does exist. The objective of this study is to describe the excess of

*Corresponding author: Facultad de Ciencias Químicas, Universidad Autónoma de Nuevo León, Ave. Universidad s/n, Ciudad Universitaria, San Nicolás de los Garza, Nuevo León, México. *E-mail address:* omargs28@yahoo.com (O. González Santiago).

defunctions that occur during the winter season in Mexico according to age and gender.

Methods

The information about the total of deaths which occurred in Mexico during the period of 2000-2012, was obtained from the National Institute of Statistics and Geography (INEGI by its Spanish acronym).[7] The information was divided according to month of occurrence, winter season (January, February, March, and December), gender and the following age groups: children, ≤9 years old; teenagers, 10-19 years old; young adults, 20-39 years old; adults, 40-59 years old, and elderly, >60 years old. For the purpose of this study, all months were standardized to 30 days. If the month had 31 days, a deduction of 1/31 of the total of deaths occurred was deducted in said month. If the month had 28 days, an addition of 2/28 of the total of deaths occurred in that month was made. In the case of leap years, an addition of 1/28 was made to February. The percentage of monthly mortality was calculated in proportion to the average annual number of deaths. The utilized formula was the following: (deaths in month *x* × 100) / average annual number of deaths. When the result equals 100% the mortality rate of that particular month is considered to be equal to the annual average. To calculate the excess of deaths in winter, we used the coefficient of seasonal variation in mortality (CSVM) with the following formula:[4] CSVM = [deaths (Dec + Jan + Feb + Mar)] – [Death (April + May + Jun + Jul) + deaths (Aug + Sep + Oct + Nov) / 2]. Everything divided by [deaths (Apr + May + Jun + Jul) + deaths (Aug + Sep + Oct + Nov) / 2]. In order to evaluate the tendency in the studied period, we used a lineal regression with natural CSVM logarithms and proved with the Student's *t*-test.

Ethical considerations

Because the data used in this study are public domain, easily accessible through INEGI (www.inegi.org.mx), and given the retrospective native of this study, we did not consider the approval of an Ethics Committee. It is noteworthy that this database does not publish personal information.

Results

During the studied period, a total of 6,679,437 deaths occurred in Mexico. The months with the highest death rates were January and December, with 50,107 and 49,881 respectively. The lower average values were June and September, with 39,152 and 40,003 deaths respectively. The monthly percentage variation with respect to the annual average is presented in figure 1. In the month of January we
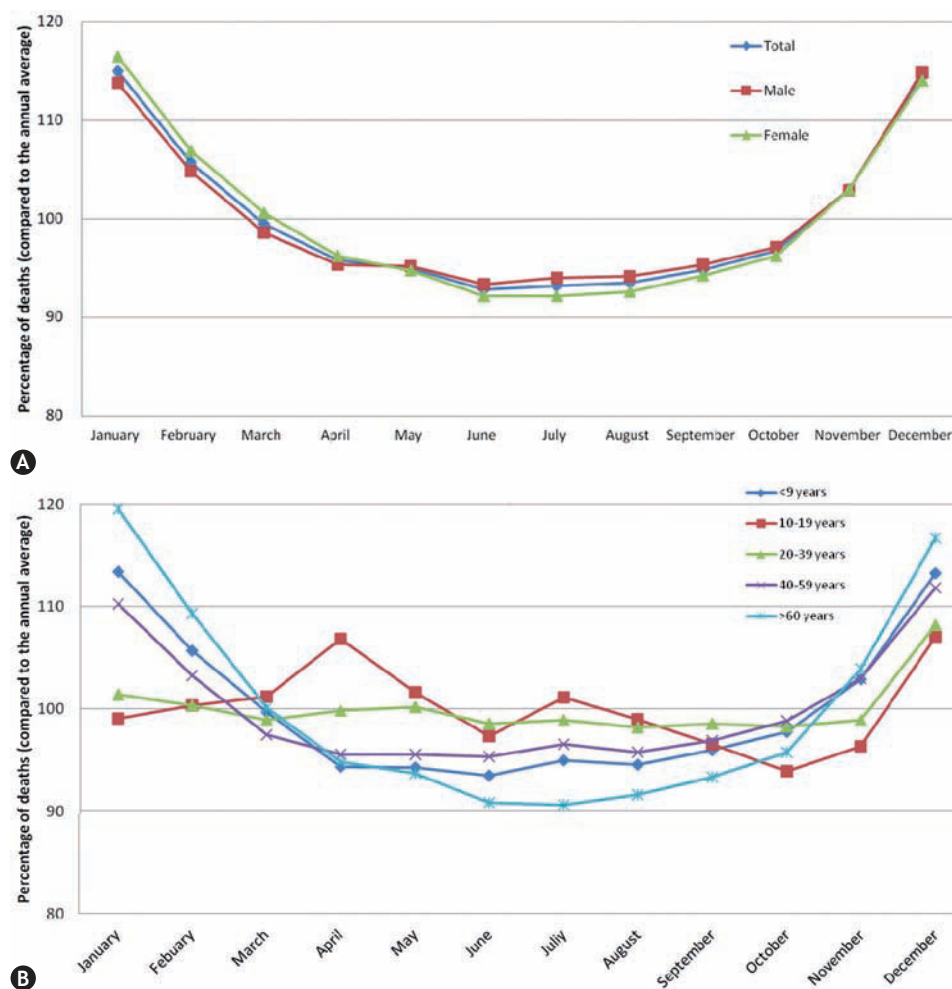

Figure 1 Percentage of monthly mortality by gender **(A)** and age **(B)** during the period 2000-2012.

observed the highest mortality rates for both genders, while the lowest was in June. According to gender, women scored a higher percentage than men in the month of January while in June the opposite occurred. According to age groups, children and the elderly peaked in mortality in January; young adults and adults in December and teenagers in April. On the other hand, the months with the lowest mortality rates were April for children, October for teenagers, June for young adults and adults and finally September for the elderly.

Mexico experienced an increase in death rates of 14% (CSVM=0.14) during the winter season. Women (CSVM=0.15) had more deaths than men (CSVM=0.13). Furthermore, the elderly and children are the age groups most susceptible to the winter season than any other age group (CSVM=0.18 and 0.13 respectively) (table 1). Throughout the studied period, all groups presented a significant lowering tendency ($P \leq .05$) (figures 2A and B).

Table 1 Coefficient of seasonal variation in mortality (CSVM) and its 95% confidence interval (95%CI) in Mexico by age group and gender

Characteristic	CSVM (95%IC)
Gender	
Total	0.14 (0.12-0.16)
Male	0.13 (0.11-0.15)
Female	0.15 (0.13-0.17)
Age	
1-9 years	0.13 (0.10-0.15)
10-19 years	0.03 (0.01-0.05)
20-39 years	0.03 (0.02-0.05)
40-59 years	0.09 (0.07-0.10)
>60 years	0.18 (0.16-0.20)

Discussion

This study describes the increase of deaths which occurred during the winter season in Mexico. Similar to other countries, the months with the highest percentage of mortality are those corresponding to said season. The increase of 14% in deaths during this season is similar to that previously reported by some European countries like Austria, Belgium, France and Italy (CSVM=0.13) and lower than those in Spain, Portugal and Ireland (CSVM=0.21, 0.28, and 0.21 respectively).[4]

Different studies have shown that intense winters and hot summers are associated with increases in mortality. In the
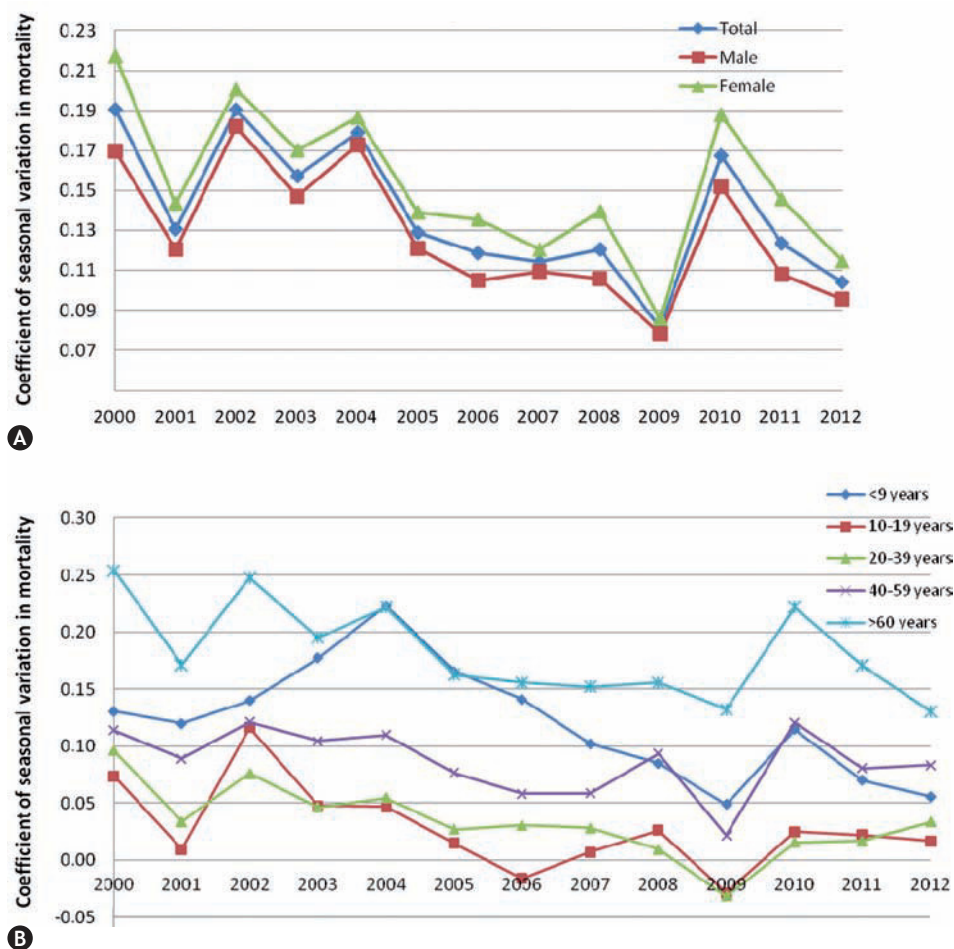

Figure 2 Coefficient of seasonal variation in mortality in Mexico by gender **(A)** and age group **(B).**

case of winters, an increase in mortality has been observed due to cardiovascular causes and respiratory infections.[6] This seasonal variation is due in part to infections with influenza, respiratory syncytial viruses and perhaps aggregated bacterial infections. It is worth stressing that during the winter months there is also an increase in the levels of air pollutants, especially particles lower than 10 μm (PM_{10}) and 2.5 μm ($PM_{2.5}$) in urban areas. These have been associated with increases in mortality due to cardiovascular causes.[8-11]

The lowest mortality percentages for the age groups <9, 40-59 y >60 years were in the summer months. This could be because there is less overcrowding, hence less infection transmission. During these months, many people, especially students, have long vacation periods that may influence health in a positive way. The beneficial effect of vacations has been described in some studies[12,13]. In contrast to the rest, the 10-19 years old age group presented increases in mortality percentages during the summer and spring months. It is possible that diarrheal diseases are some of the main causes of this result, given the fact that during this period they increase considerably.

Even though all groups presented a lowering tendency in their CSVM, in the year 2010 there was a sudden increase in winter deaths. The lowering tendency can be seen again in 2011. It is possible that this sudden increase in 2010 was caused by the emergence of the H_1N_1 Influenza virus in 2009. It is worth noting that in the year 2010 health authorities established a vaccination plan against the H_1N_1 influenza virus where priority was given to children under 4 years of age, pregnant women and people over 60 years of age.[14,15]

Even though the increase in deaths during winter may seem common to many countries, the magnitude of this increase differs between developed countries and developing countries. The improvement of living conditions, which lead to lower variation in interior temperature with respect to outside temperature, may be related to the lowering of mortality in winter as well as in summer in developed countries.[16]

This study has limitations, and the results should be interpreted carefully because it wasn't possible to rule out a sub-register of the deaths reported in the INEGI's database. Additionally, Mexico has great climatic variability within its territory and it is possible that the 14% increase in winter deaths could be very different in some of its regions.

Conclusions

The increase of deaths by 14% during winter in Mexico is considerably high. Children and people over 65 years of age are the most susceptible age groups. Given the high varia-

tion of temperatures throughout the country, it is necessary to conduct further studies regarding the different regions in Mexico.

References

1. Doyon B, Bélanger D, Gosselin P. The potential impact of climate change on annual and seasonal mortality for three cities in Québec, Canada. Int J Health Geogr. 2008;7:23.
2. Olson AL, Swigris JJ, Raghu G, Brown KK. Seasonal variation: mortality from pulmonary fibrosis is greatest in the winter. Chest. 2009;136:16-22.
3. Eccles R. An explanation for the seasonality of acute upper respiratory tract viral infections. Acta Otolaryngol. 2002;122:183-91.
4. Healy JD. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. J Epidemiol Community Health. 2003;57:784-9.
5. Davie GS, Baker MG, Hales S, Carlin JB. Trends and determinants of excess winter mortality in New Zealand: 1980 to 2000. BMC Public Health. 2007;7:263.
6. Falagas ME, Karageorgopoulos DE, Moraitis LI, Vouloumanou EK, Roussos N, Peppas G, et al. Seasonality of mortality: the September phenomenon in Mediterranean countries. CMAJ. 2009;181:484-6.
7. Instituto Nacional de Estadística y Geografía (INEGI). Estadísticas de Mortalidad [cited Dec 2013]. Available from: http://www.inegi.org.mx/sistemas/olap/proyectos/bd/consulta.asp?p=mortgral&c=33465&s=est&cl=4#
8. Keatinge WR. Winter mortality and its causes. Int J Circumpolar Health. 2002;6:299.
9. Pope CA III, Dockery DW. Health effects of fine particulate air pollution: lines that connect. J Air Waste Manage Assoc. 2006;56:709-42.
10. Gomiščeka B, Haucka H, Stoppera S, Preining O. Spatial and temporal variations of PM1, PM2.5, PM10 and particle number concentration during the AUPHEP-project. Atmos Environ. 2004;38:3917-34.
11. Chaloulakou A, Kassomenos P, Spyrellis N, Demokritouc P, Koutrakis P. Measurements of PM10 and PM2.5 particle concentrations in Athens, Greece. Atmos Environ. 2003;37:649-60.
12. Chikani V, Reding D, Gunderson P, et al. Vacations improve mental health among rural women: the Wisconsin Rural Women's Health Study. WMJ. 2005;104:20-3.
13. Fritz C, Sonnentag S. Recovery, well-being, and performance-related outcomes: the role of workload and vacation experiences. J Appl Psychol. 2006;91:936-45.
14. Alonso Reynoso C. La influenza A (H1N1) y las medidas adoptadas por las autoridades sanitarias. Desacatos. 2010;32:35-52.
15. PROYECTO de Modificación de la Norma Oficial Mexicana NOM-036-SSA2-2002. DOF: 28/02/2012.
16. Gemmell I, McLoone P, Boddy FA, Dickinson GJ, Watt GC. Seasonal variation in Mortality in Scotland. Int J Epidemiol. 2000;29:274-9.