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Mortality in Kuwait: Pattern and Seasonality

Key Words

Mortality statistics
Life tables
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Abstract

This paper examines total and cause-specific mortality of the Kuwaiti population through a variety of life table models. Seasonality of diseases underlying mortality was also measured using the Fourier (cosinor) analysis. Results showed significant decline in total and infant mortality. Life table analysis showed that cardiovascular disease, accidental injury and malignant disease were the main causes of death in Kuwait and that ischemic heart disease was the major component of cardiovascular disease. The Fourier analysis showed a winter peak seasonality in January for total mortality, cardiovascular and respiratory diseases, and no seasonality for malignant disease, congenital anomalies or perinatal disease. Overall, Kuwait has the seasonal timing of developed countries for total mortality, cardiovascular and respiratory diseases due to the rapid changes in the life-style of people towards westernization. In conclusion, the study demonstrated the usefulness of national mortality statistics in measuring the force of mortality, and the ability of life table methods to assess the various roles that diseases may exhibit in the death process.

Introduction

In Kuwait, national mortality statistics are based on information contained on death certificates filed in the death registry as required

by state law. This information is compiled by the Vital and Health Statistics Department, Ministry of Health for monitoring the state's health as well as for health planning and research. Cause-specific mortality statistics

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are based on the underlying cause of death model that assumes that death is a unidimensional process. This implies that a single disease or medical condition may be designated as the underlying cause of death if it initiated the sequence of morbid events that led to death [1]. In spite of the limitations of death certification [2], mortality statistics have an important role in setting priorities for health planning and research.

In view of the economic and social changes now occurring in Kuwait and improvements in hygiene, living standards, health care, and medical facilities, current trends in mortality and seasonality of diseases are of considerable importance. Mortality statistics are conventionally used to calculate rates and indices of mortality which are routinely published. The current paper presents two methodological approaches for the analysis of mortality data, namely life tables and disease seasonal variations, with application to Kuwait data in order to demonstrate the usefulness of national mortality statistics in measuring the force of mortality. This paper provides new information about mortality in Kuwait, since life tables and seasonality of diseases underlying mortality in Kuwait are not routinely published. Such new data may be used by the health authorities for the modification of certain behavioral factors that would prevent or control some causes of mortality.

In this paper, we studied the recent changes in the pattern and level of mortality for Kuwaiti and non-Kuwaiti sub populations. This included: (1) total mortality indices and life tables with sex, age and nationality differentials; (2) cause-specific mortality including multiple-decrement and cause-elimination life tables, and (3) seasonality of mortality due to different diseases.

Materials and Methods

Data were obtained from the Death Registry, Ministry of Health, Kuwait for the years 1987–1989 and 1992–1993. Mortality data for the 2 years 1990 and 1991 were excluded due to the interruption caused by the Iraqi occupation. Mortality data included age, sex, nationality and underlying cause of death according to the International Classification of Diseases, ninth revision, ICD-9 [3]. Data on population (the denominator) were obtained from the Ministry of Planning [4].

To take into account the changes in the age structure of the population in Kuwait between 1987 and 1993, adjusted death rates for age, sex and nationality were calculated by the direct standardization method using the Kuwait census population of 1985 as the standard population. Adjusted death rates show changes in mortality over the studied period. Linear trend in adjusted death rates was tested using the chi-square test for linear trend [5].

Life Tables

Life tables for total mortality, multiple decrement and cause elimination were constructed [6, 7]. Since fluctuations in mortality rates are likely to be large when a small number of deaths occur, as in a small population like Kuwait, mortality rates were based on the 5 years' average of deaths as numerator and the average mid-year population of the studied years as denominator. Assuming that a given disease is the only cause of death operating on the population, the multiple-decrement life table provides the life expectancy at different ages. Comparing these life expectancies with those under total mortality will indicate the weights of different diseases in the death process.

Cause-elimination life tables address the potential changes in mortality patterns that would occur if a given disease was eliminated. A frequently used measure is the cause-elimination life expectancy gain. The value of this measure represents the change in life expectancy of the general population that would happen under the hypothetical complete or partial elimination of a disease.

Seasonality

We used Fourier (cosinor) analysis [8, 9] to determine the significance of seasonal variation of mortality. This technique is reliable in case monthly mortality data has a single peak and fits a single sinusoidal curve. Requirements to apply this technique were satisfied in our data, since the distribution of the number of deaths during the months was unimodal; in addition, we

Table 1. Annual age-adjusted¹ death rates (per 1,000 population), Kuwait, 1987–1993

	1987	1988	1989	1992	1993	χ^2 for linear trend	p
<i>Kuwaiti males</i>							
Age-adjusted death rate	3.75	3.76	3.55	3.55	3.18	17.2	<0.001
Odds ratio	1.00	1.00	0.95	0.95	0.85		
<i>Kuwaiti females</i>							
Age-adjusted death rate	3.24	3.37	3.27	3.03	2.97	8.1	0.004
Odds ratio	1.00	1.04	1.01	0.94	0.92		
<i>Non-Kuwaiti males</i>							
Age-adjusted death rate	1.92	1.83	1.78	1.96	2.18	13.3	<0.001
Odds ratio	1.00	0.95	0.93	1.02	1.12		
<i>Non-Kuwaiti females</i>							
Age-adjusted death rate	1.32	1.45	1.35	1.18	1.16	10.2	0.001
Odds ratio	1.00	1.10	1.02	0.89	0.88		

¹ The standard population is the Kuwait 1985 census population.

tested the goodness of fit of the observed monthly mortality data to different models and the unimodal sinusoidal curve provided the best fit for our data. Fourier analysis takes into account the varying length of months (28–31 days), since the expected number of deaths were weighted by the number of days in each month. In fact, the number of observed deaths during the shortest month (February) in our data was higher than the number of deaths during 5 of the 31-day months: March, May, July, August and October. In the cosinor analysis, the year is taken as 360 degrees and the midpoint of each month of the year is assigned an angular value, t , for January (15 degrees) through December (345 degrees). Multiple regression analysis is then performed between monthly mortality data as the dependent variable and $\sin(t)$ and $\cos(t)$ as independent variables. This analysis provides the multiple correlation coefficient (r), its statistical significance level (p), and the angular position in the year in degrees (converted to the nearest month) where the fitted sinusoidal regression line has its highest value. To stabilize reached estimates from the cosinor analysis, monthly mortality data were taken as the sum of the 5-year deaths in respective months.

We calculated the monthly mean number of deaths predicted by the multiple regression that was given a value of 100%. Individual months were expressed as a

percentage above and below this mean. The extent of the seasonal fluctuation is called the *amplitude*. The amplitude was measured as the percentage above the mean for the month of the highest value (the peak). Significance refers to the presence or absence of seasonality. The value of r given by the cosinor analysis provides a guide to the magnitude of seasonality of mortality due to different diseases.

Results

Table 1 exhibits the annual age-adjusted death rates by sex and nationality for the 5 years under study; death rates were higher in Kuwaitis than in non-Kuwaitis, and higher in males than in females. There was a declining linear trend in total mortality after taking into account the changes in the age structure of the population during the study years, except non-Kuwaiti males in whom mortality rates increased during 1992 and 1993. The male:female death ratio during these 5 years was

Table 2. Infant mortality rates¹, Kuwait 1987–1993

	Male	Female	Total
<i>Kuwaitis</i>			
1987	18.88	15.63	17.26
1988	16.77	13.61	15.23
1989	14.96	11.72	13.36
1992	13.07	9.87	11.51
1993	12.01	10.42	11.23
<i>Non-Kuwaitis</i>			
1987	19.15	16.01	17.59
1988	17.71	16.38	17.06
1989	16.70	14.19	15.48
1992	13.84	12.78	13.32
1993	15.99	13.00	14.53

¹ Rate per 1,000 live births.

1.44:1 for Kuwaitis and 1.89:1 for non-Kuwaitis, while the male:female population ratio was 1.06:1 for Kuwaitis and 1.54:1 for non-Kuwaitis.

In addition, there was a steady decline in infant mortality rates in Kuwaitis from 17.3 in 1987 to 11.2 (per 1,000 live births) in 1993. Infant mortality rates were consistently higher among non-Kuwaitis than Kuwaitis and, overall, declined from 17.6 in 1987 to 14.5 in 1993. Moreover, infant rates were higher in males than females (table 2).

The life expectancy at birth of a Kuwaiti male was 72.1 years, while that of a Kuwaiti female was 76.10 years. On the other hand, non-Kuwaiti males and females had life expectancies at birth of 72.19 had 77.98 years, respectively, with a difference of 5.79 years (table 3). Life expectancies for females exceeded those for males in all age-groups and in both Kuwaitis and non-Kuwaitis.

Table 4 presents the Kuwaiti male (abbreviated) multiple-decrement life table for cardiovascular diseases (CVD; ICD-9, 401–405;

Table 3. Life expectancies abstracted from current (abbreviated) life tables based on total mortality data of 5 years (1987–1989 and 1992–1993)

Age at start of interval x	Life expectancies, e^0_x			
	Kuwaitis		non-Kuwaitis	
	males	females	males	females
0	72.10	76.10	72.19	77.98
1	72.22	76.06	72.25	77.97
5	68.44	73.22	68.47	74.16
10	63.60	68.32	63.62	69.26
15	58.75	63.40	58.76	64.33
20	54.09	58.48	53.92	59.41
25	49.43	53.57	49.07	54.48
30	44.72	49.66	44.20	49.58
35	40.05	44.79	39.37	44.69
40	35.38	39.95	34.57	39.83
45	30.71	34.20	29.81	34.98
50	26.17	30.64	25.17	30.25
55	22.03	25.34	20.72	25.76
60	18.07	21.36	16.48	21.37
65	15.06	17.94	12.88	17.46
70	11.98	12.00	9.27	13.68
75	9.65	10.64	6.71	10.86
80	7.44	8.18	4.31	7.70
85+	5.77	6.56	2.70	5.41

410–414; 430–438). Similar tables were computed for Kuwaiti females, non-Kuwaiti males and non-Kuwaiti females for CVD and the following groups of diseases: malignant, respiratory, infection and parasitic, and accidental injury. These are however not shown due to space considerations. Assuming that CVD was the only cause of death, λ , operating on the Kuwaiti male subpopulation, the average age of death at birth, $e^0\lambda$, was 75.7 years as compared to 72.1 years for total mortality (table 3). Life expectancy differentials between total mortality and CVD alone became more apparent at advanced ages when CVD starts to operate. This emphasizes the increasing risk of CVD on mortality at higher ages.

Table 4. Kuwaiti male multiple-decrement life table for CVD based on mortality data for 5 years (1987–1989 and 1992–1993)

Age at start of interval x	Probability of dying in interval $q_{x\lambda}$	Number living at age x $l_{x\lambda}$	Number dying in interval $d_{x\lambda}$	Observed life expectancy at age x $e^0_{x\lambda}$
0	0.000018	35,406	2	75.68
1	0.000000	35,404	0	74.68
5	0.000089	35,404	9	70.68
10	0.000051	35,395	5	65.70
15	0.000152	35,390	15	60.71
20	0.000148	35,375	14	55.73
25	0.000585	35,361	56	50.75
30	0.000977	35,305	94	45.83
35	0.001521	35,211	145	40.94
40	0.003937	35,066	371	36.10
45	0.006014	34,695	562	31.46
50	0.015276	34,133	1,403	26.93
55	0.022663	32,730	2,008	22.97
60	0.056357	30,722	4,737	19.28
65	0.065988	25,985	4,169	17.32
70	0.090220	21,816	5,822	15.14
75	0.096133	15,994	4,834	14.74
80	0.136593	11,160	4,935	15.05
85+	0.288503	6,225	6,225	9.77

The number of persons in a hypothetical initial birth cohort of 100,000 who will ultimately die due to one of the five studied disease groups was estimated by the multiple decrement life tables. Comparing these numbers indicated the magnitude of contribution of each disease to mortality; the highest mortalities were estimated to die due to CVD. Accidental injury, which is mainly due to motor vehicle accidents, caused more than double the mortalities in males than in females. CVD were further studied by breaking them into: hypertensive disease (ICD-9, code 401–405), ischemic heart disease (ICD-9, code 410–414) and cerebrovascular disease (ICD-9, code 430–438). Ischemic heart disease and hypertensive disease were the underlying causes of deaths in a majority of males and females, respectively.

Table 5 displays the Kuwaiti male cause-elimination life table for CVD. Similar tables were computed for Kuwaiti females, non-Kuwaiti males and non-Kuwaiti females for CVD and other disease groups. These are not shown due to space limitation. Under the assumption of hypothetical elimination of CVD from the general population, the life expectancy at birth of a Kuwaiti male increased from 72.1 (table 3) to 77.53 years. The life expectancy gain (5.43 years) may be attributed to the elimination of CVD from the population.

For example, the health authorities in Kuwait may adopt a long-term plan aiming at reducing CVD by 20%, malignant disease by 10%, accidental injury by 30%, respiratory disease by 20% and infection and parasitic disease by 40%. After implementing the necessary intervention programs the plan may be

Table 5. Kuwaiti male cause-elimination life table for CVD based on mortality data of 5 years (1987–1989 and 1992–1993), Kuwait

Age at start of interval x	Probability of dying in interval $q_{x\lambda}$	Number living at age x $l_{x\lambda}$	Number dying in interval $d_{x\lambda}$	Observed life expectancy at age x $e^0_{x\lambda}$
0	0.01534	100,000	1,534	77.53
1	0.00300	98,466	296	77.73
5	0.00232	98,170	228	73.96
10	0.00238	97,942	233	69.13
15	0.00587	97,709	574	64.29
20	0.00643	97,135	625	59.65
25	0.00570	96,510	550	55.02
30	0.00671	95,960	644	50.33
35	0.00726	95,316	692	45.65
40	0.00587	94,624	555	40.96
45	0.01027	94,069	966	36.19
50	0.02032	93,103	1,892	31.54
55	0.02882	91,211	2,628	27.14
60	0.05967	88,583	5,285	22.86
65	0.07967	83,298	6,637	19.14
70	0.13711	76,661	10,511	15.57
75	0.19566	66,150	12,943	12.62
80	0.28842	53,207	15,346	10.07
85+	1.00000	37,861	37,861	8.11

evaluated by the cause-elimination life expectancy gain in the general population as a result of these interventions. Applying this health plan using our mortality data, the life expectancy at birth for a Kuwaiti male increased to 74.10 years as compared to 72.10 years for total mortality (table 3). This life expectancy gain of 2 years results from the elimination of specific proportions of respective diseases.

Cosinor analysis showed that total and CVD mortalities had winter-peak seasonality in January (table 6, fig. 1), while respiratory disease mortality showed the highest significant peak in January–February, as seen from the magnitude of r , p and the amplitude. Cosinor analysis did not show any significant seasonality for malignant diseases, infection, parasitic, and congenital anomalies, and perinatal diseases.

Although the number of deaths was small in each year, we studied the seasonality pattern of total mortality from year to year. Cosinor analysis showed higher amplitude during the years 1987–1989 (amplitude = 12.4, 12.4 and 15.0% in 1987, 1988, and 1989, respectively) than the years 1992 and 1993 (amplitude = 7.1 and 10.9% for 1992 and 1993, respectively). However, there was a significant winter-peak seasonality in January for the 5 years under study.

Discussion

The findings of this study are limited by errors inherent in any mortality data derived from death certificates. We recognize the limitations of death certification [2]. We believe

Table 6. Cosinor analysis based on mortality data of 5 years (1987–1989 and 1992–1993), Kuwait

Disease group	% of total mortality	Cosinor analysis			
		r	p	amplitude	peak month
Infection/parasitic	3.1	0.604	0.129	16.4	–
Malignant	11.5	0.327	0.601	3.6	–
Circulatory	33.8				
Cardiovascular	(25.7)	0.827	0.006	15.1	January
Ischemic heart disease (ICD 410–414)	(15.5)	0.896	0.007	14.9	January
CVD (ICD 430–438)	(3.0)	0.589	0.147	8.3	–
Hypertensive disease (ICD 401–405)	(7.2)	0.797	0.011	21.7	January
Respiratory	6.3	0.854	0.003	20.8	January–February
Congenital anomalies	6.6	0.398	0.459	5.7	–
Perinatal	7.7	0.293	0.668	4.2	–
Symptoms, signs and ill-defined conditions	4.9	0.676	0.064	16.1	–
Injury/poisoning	14.9	0.296	0.661	4.3	–
Others	11.2	0.580	0.436	10.8	–
Total	100	0.793	0.012	11.4	January

that our conclusions are justified because of the wide disease groupings pooled over a time span of 5 years. The change in cause-specific mortality rates has important implications for the planning of health care, disease prevention, health promotion, and clinical research.

The number of male deaths in Kuwait during the study period was almost 1.5 times as large as female deaths because of the large non-Kuwaiti workforce from other countries who are mostly males in the working age-group. There was a declining trend in death rates consistently with the global mortality trend as a consequence of improvement in health care, diagnostic procedures, specialized hospital equipment, ambulance transport, and disease prevention programs. Differences in death rates between Kuwaitis and non-Kuwaitis may reflect variations in factors such as socioeconomic, access to medical

care, selective migration, and the prevalence of specific risks due to inherent diseases.

Our data also showed a decline in infant mortality rate in Kuwaitis from 17 in 1987 to 11 per 1,000 live births in 1993, and in non-Kuwaitis infant mortality declined from 17.6 in 1987 to 14.5 in 1993. This is in accordance with the international declining pattern of infant mortality. Wegman [10] reported a decline of the USA infant mortality rate to 8.5 in 1992. The declining pattern continued to reach 8.4 in 1993, and 7.4% in 1994 [11]. On the world scene, most industrialized countries showed a decline in infant mortality with the lowest rate recorded in Japan (4.4). In comparison with other countries in the region, Kuwait maintained the lowest level of infant mortality rate. In 1992, the infant mortality rate was 20 in Bahrain, 67 in Iraq, 39 in Jordan, 46 in Lebanon, 44 in Oman, 26 in Qatar, 65 in Saudi Arabia, 48 in Syria, 25 in United

Fig. 1. Total mortality. Monthly data for all deaths are expressed as a percentage of the mean monthly value. Cosinor analysis ($r = 0.793$, $p = 0.012$, amplitude = 11.4% with peak in January). ● = Observed mortality; — = predicted mortality.

Arab Emirates, 40 in Yemen, and 73 in Egypt [12].

The death composition in Kuwait (table 6), based on the actual observed mortality data, showed that CVD was the first underlying cause of death followed by accidental injury (14.9%) and malignant disease (11.5%). Ischemic heart disease represented the major component of CVD, while motor vehicle accidents constituted a large proportion of accidental injury. The aggravation of fatal car accidents led the Kuwaiti government to impose mandatory wearing of seat belts in 1994. Higher mortalities due to CVD in Kuwait may be attributed to the rapid changes in the life-style of people towards westernization. These changes included less physical activity as a result of availability of modern means of

transport and communication, and excessive intake of high calorie diet.

Kuwait had the highest life expectancy at birth in males and females compared to other countries in the region. In 1992, the male/female life expectancies in years for these countries were: Bahrain 70/74, Iraq 66/68, Jordan 69/73, Lebanon 66/70, Oman 64/68, Qatar 69/74, Saudi Arabia 63/66, Syria 64/66, United Arab Emirates 69/73, Yemen 48/51, and Egypt 58/61 [12]. Comparison of the total mortality life expectancy with that of the multiple-decrement life table provides an indication of the role of such disease on mortality through quantifying its force of mortality. The multiple decrement life table for an underlying cause assumes that such a cause is the only one operating on the population while fixing

the effect of other causes. For example, the preponderance of CVD as an underlying cause of death in males can be revealed by the life table models from different aspects. Firstly, the number of males in an initial birth cohort who will ultimately die of CVD was the highest. Secondly, the life expectancy at birth of the multiple-decrement CVD was low as compared to other causes. Thirdly, the average number of years of life lost due to CVD was the highest.

Kuwait has the seasonal timing of the developed countries for total mortality and mortalities due to cardiovascular and respiratory diseases with a winter peak seasonality in January. This result is in concert with another study [9]. The biological reasons for higher occurrence of total mortality and mortalities due to CVD (which underly the majority of deaths) in winter are not known, but some possible mechanisms may be suggested [13, 14]. Exposure to cold causes peripheral vasoconstriction and increase in blood pressure [15, 16]. Furthermore, total cholesterol and triglycerides tend to be higher in winter than in summer [17]. Perhaps, most importantly, plasma fibrinogen increases in winter and raises blood viscosity [18, 19]. Although seasonal variations in other factors such as air pollution, incidence of influenza, and diet have also been suggested to play a role, variation in temperature has been considered the most likely reason [20, 21]. Mortality peak in Kuwait during winter may result from the fall in temperature in early winter, rather than the magnitude of the absolute low temperature reached in later winter. This result is in concert with other studies [9, 13].

This study is consistent with that of Rothwell et al. [22] and shows no significant seasonal variation in mortality due to CVD (table 6). In contrast Jakovljević et al. [14] reported significant seasonal variations of CVD during winter in Finland.

Our findings cannot necessarily be compared with those in countries where the climate or the pathology of diseases differ from those in Kuwait. Further research taking into account meteorological factors, such as daily temperature, humidity, and barometric pressure, as well as certain sociodemographic and behavioral factors may help to explain the observed seasonal differences and to determine ways to prevent excess mortalities in winter.

In conclusion, this study demonstrated the usefulness of national mortality statistics in measuring the force of mortality. It also indicated that the richness of the cause-specific mortality data can be fully exploited by the life table methods for assessing the various roles that diseases may exhibit in the death process. The study highlights the fact that Kuwait has the seasonal timing of the developed countries for total mortality and CVD due to the rapid changes in the life-style of people towards modernization.

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