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Seasonal variations of mortality in Hong Kong

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Abstract

This study investigated seasonality of mortality in Hong Kong from 1980 to 2005 using cosinor analysis. Mortality data from all causes of death, neoplasm, circulatory and respiratory diseases were obtained from the Census and Statistics Department. Statistically significant seasonalities were ascertained for total and gender-specific deaths from all causes, circulatory and respiratory diseases, but not neoplasm. The amplitudes of seasonal fluctuations were low. Also, amplitudes of seasonality increased with age and conspicuous increase in amplitudes at age group ≥65 was detected. The timing of the peak for significant rhythms was in February and March.

Key words: mortality, seasonality, cosinor analysis, Hong Kong

1 Introduction

The awareness of the influence of seasons on human health has long been existed since Hippocrates. Quetelet (1842) was the first to collect data and study the effect of seasons in mortality. Sokamoto-Momiyama (1977) examined mortality seasonality in Japan since 1899, when there were a large summer peak and a small winter peak; and discovered the disappearance of a summer peak in 1960s, when a winter peak developed. Thereafter, there is growing interest in the investigation of seasonal variations in mortality, and it is noted that mortality is generally higher in winter (e.g. Bako et al. 1988; Douglas et al. 1991a, 1991b; Douglas and Rawles 1999; Gemmell et al. 2000; Feinstein 2002; Nakaji et al. 2004).

Many previous studies on mortality seasonality focus on the temperate regions, and research of this subject in the tropics currently receive increasing attention. Maximum mortality was found during the rainy season in Costa Rica (Madrigal 1994) and Sri Lanka (Motohashi et al. 1996). Children mortality also peaked at the rainy season in sub-Saharan Africa (Abdullah et al. 2007). Seasonal patterns of deaths were discovered in Kuwait (Douglas, 1991b) and Bangladesh (Becker and Weng 1998).

In Hong Kong, winter peaks were found in mortality from all causes, circulatory and respiratory diseases (Yan 2000; Yip et al. 2007). Since there is limited literature on mortality seasonality in Hong Kong, research on this subject can shed light on the influence of seasonal factors on mortality in the sub-tropical regions. The objectives of this study are to evaluate the existence of seasonality of morality using cosinor analysis and to determine whether there are seasonal changes in mortality for the period from 1980 through 2005.

2 Materials and methods

2.1 *Mortality data*

Mortality data from various diseases for the period from 1980 to 2005 were obtained from the Hong Kong Census and Statistics Department. Since 2001, the classification of cause of death is based on the 10th Revision of the International Classification of Diseases (ICD). Mortality from all causes and leading causes of death, that comprised

neoplasm (malignant) (32.5%), circulatory system (26.2%) and respiratory diseases (18.3%) in 2005 (Department of Health, 2006), were selected for analysis in this study and were showed in Table 1.

The daily mortality data were grouped in monthly values, that were further divided into gender and age groups ≤24, 25-44, 45-64 and ≥65. These monthly gender and age specific mortality data were then divided by their corresponding annual mid-year population to eliminate the impact of population growth. Further, these adjusted monthly mortality data were then standardized to a 30.5 day average to correct for the monthly differences in number of days.

2.2 *Statistical analysis*

Single cosinor models were used to ascertain seasonal rhythms in the selected causes of deaths. The standardized mortality data for each month throughout the 26 years were used for the cosinor analysis, that assumes periodical oscillation of a set of biological temporal data to be explained by a sinusoidal curve (Nelson et al. 1979).

Cosinor models were fitted to each annual cycle to generate parameters of the cosine curve approximation that are mesor, amplitude and acrophase. Mesor, the midline-estimating statistic of rhythm, is the mean level of the cosine curve. The amplitude is the difference between the mesor and the peak of the cosine curve. The acrophase is the time when the peak occurs and is measured in degrees that 0^o-30^o represents January, 30^o-60^o February and so on. A rhythm is considered statistically significant when the hypothesis of zero amplitude (no rhythm) is rejected when α =0.05. Acceptance of the zero amplitude hypothesis implies that either the data are constant with time or the cosinor model is inappropriate (Nelson et al. 1979).

To investigate the seasonal changes in mortality of selected causes that had statistically significant seasonal rhythms, difference percentage between mortality rates in the peak and lowest months was calculated for each year. This difference percentage indicated the effect of seasonality. Linear regression was employed to assess the changes in seasonality impact over the study period.

3 Results

During 1980-2005, the average mortality from all causes was 497.83 deaths per 100,000 population; and higher average death rates from selected causes were found in male and age groups ≥45 (Table 2). Deaths at younger age groups (i.e. age ≤24 and age 25-44) from CVD and IHD were excluded in the examination of seasonality because of their minimal average mortality rates.

Table 3 presents the parameters estimated from single cosinor analysis for the selected causes of deaths for the study period. Seasonality was not observed in neoplasm. Statistically significant seasonalities were ascertained for total and gender-specific deaths from all other selected causes. No gender difference in mortality seasonality was discovered. However, the amplitudes of seasonal fluctuations were low. For the various age groups, amplitudes of seasonality increased with age and conspicuous increase in amplitudes at age group ≥65 was detected. Nonetheless, no significant

seasonality was found in the younger age groups from all causes and circulatory diseases.

The acrophase or the timing of the peak for significant rhythms for deaths from all causes, circulatory diseases, CVD and IHD varied from 50^{o} to 67^{o}, i.e. in February to early March. For respiratory diseases, significant mortality peaks occurred predominately in March.

Statistically significant decline in seasonal changes of mortality was observed only at age group ≥65 from all causes. Difference percentage dropped form 49.73 in 1980 to 39.92 in 2005 (β=-0.814, r^2=0.353, p=0.001).

4 **Discussion**

The results of the present study reveal significant annual periodicities in mortality from all causes, circulatory and respiratory diseases. However, mortality seasonality in neoplasm was not found, and this finding is in agreement with previous study (Yan 2000) although Allan (1966) discovered the highest deaths from cancers in Britain were in the fourth quarter of the year.

The amplitude of seasonality was found to be fairly low ranging from 0.79 to 4.79 for total deaths from CVD and all causes respectively. The seasonal rhythm of mortality is the greatest in the mid-latitude and lowest or absent near the equator and in the sub-polar regions (Douglas and Rawles 1999). The subtropical climate with small seasonal temperature fluctuations plausibly attribute to the low amplitude in Hong Kong.

The findings that no sex differences in relation to seasonal mortality was consistent with previous studies (e.g. Yan 2000; Gemmell et al. 2000) but different from the study by Rau and Doblhammer (2003) who discovered that males showed larger seasonal fluctuation in mortality and this seasonality began at an earlier age than females.

Age plays an important role in seasonal variations in mortality. An increase in amplitude with age was discovered. This result indicates the change in the sensitivity towards the environment with age. The younger age groups are less vulnerable to weather effects while the elderly are more susceptible to weather stress. This is mainly because of weakening homeostatic defense mechanism with advancing age that facilitates the onset of hyperthermia or hypothermia that in turn would provoke circulatory and other diseases (Douglas et al. 1991a, Pan et al. 1995). In addition, the elderly might also be more sensitive to relatively small changes in weather (Seto et al. 1998) and more vulnerable to less extreme temperature changes in subtropical climate (Woo et al. 1991).

The acrophases for significant rhythms for deaths from all causes and circulatory diseases were within the range of 50^{o}-67^{o}, i.e. February to early March. This findings is consistent with the report of Yip et al. (2007) and comparable to that in the temperate regions. Lower temperatures are associated with increased mortality. Exposure to the cold increases blood pressure, blood viscosity and platelets, and heart

rate (Douglas et al. 1991a; Kunst et al. 1993; Crawford et al. 2003) and trigger circulatory diseases.

For respiratory diseases, mortality was discovered to peak predominantly in March when the mean temperature is 18.5^{o}C and relative humidity is 81%. This observation contradicts the previous report of winter dominance of respiratory mortality. However, it is similar to the peak occurrence of respiratory syncytial virus (RSV) infection in the cold wet months in Hawaii (Reese and Marchette 1991), and in the rainy season in Malaysia (Chan et al. 2002). The probable reasons for this peak in March in Hong Kong are the cool temperatures that induce cooling of nasal passages with concurrent decrease in respiratory defense (Eccles 2002) and the high humidity that is favorable to viral survival by preventing drying and loss of viral infectivity (Chan et al. 2002).

Only age group ≥65 experienced significant seasonal changes in mortality from all causes. A statistically significant decline in difference percentage between mortality rates in the peak and lowest months was detected (β=-0.814, p=0.001). This indicates a decrease in the amplitude of seasonal rhythm, that can be explained by the improvements in the public health system. In addition, a temperature warming trend at a rate of 0.61^{o}C per decade from 1989 to 2002 was found, and this warming trend was expected to continue (Leung et al. 2004). This increase in temperature because of global warming reduces the stress from cold weather and thus lowers mortality.

5 Conclusion

This study demonstrated the mortality seasonality of all causes, circulatory and respiratory diseases, and also highlighted the decline of seasonal changes in mortality of the elderly. This knowledge may help formulate public health policy and plan prevention and control programs, particularly viral respiratory infections. With increasing temperatures, deaths affected by cold weather would decrease. However, heat stress from more sizzling hot conditions would escalate mortality. The impact of climate change on seasonal variations of mortality requires further study.

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Table 1. Selected causes of death for analysis

Causes of Death	ICD-9	ICD-10
All causes	I-XVII inclusive	I-XIX inclusive
Neoplasm (malignant)	II 140-208	II C00-C97
Circulatory system	VII 390-459	IX I00-I99
Ischaemic heart disease (IHD)	410-414	I20-I25
Cerebrovascular disease(CVD)	430-438	I60-I69
Respiratory diseases	VIII 460-519	X J00-J99

Table 2. Total mortality rates of selected causes of death from 1980-2005

	All causes	Neoplasm	Circulatory	IHD	CVD	Respiratory
Total	12943.65	3982.65	3614.66	1302.45	1394.68	2254.00
	(497.83)	(153.18)	(139.03)	(50.09)	(53.64)	(86.69)
Male	14375.72	4257.33	3621.32	1386.79	1318.69	2577.24
	(552.91)	(163.74)	(139.28)	(53.34)	(50.72)	(99.12)
Female	11490.42	3078.53	3609.78	1182.56	1476.94	1930.26
	(441.94)	(118.41)	(138.84)	(45.48)	(56.81)	(74.24)
Age ≤24	2077.16	218.33	97.23	4.45	29.72	168.34
	(79.89)	(8.40)	(3.74)	(0.17)	(1.14)	(6.47)
Age 25-44	2353.61	870.67	267.64	58.76	93.73	131.26
	(90.52)	(33.49)	(10.29)	(2.26)	(3.61)	(5.05)
Age 45-64	16230.86	7122.12	3712.26	1223.83	1489.53	1613.82
	(624.26)	(273.93)	(142.78)	(47.07)	(57.29)	(62.07)
Age ≥ 65	94770.56	24492.07	31313.47	11387.98	12178.82	20451.36
	(3645.02)	(942.00)	(1204.36)	(438.00)	(468.42)	(786.59)

* mortality rates are expressed in number of deaths per 100,000 population
* the numbers in parentheses are the average number of mortality for the study period

Table 3. Parameters estimated from single cosinor analysis for the selected causes of deaths for the study period (1980-2005).

	Mesor (SE)	Amplitude (SE)	Acrophase (SE) (in degree)	Month of peak
All causes				
Total	41.49 (0.169)	4.79 (0.238)*	63.2 (2.85)	Early March
Male	46.08 (0.220)	4.99 (0.312)*	59.3 (3.58)	Late February
Female	36.83 (0.166)	4.61 (0.235)*	67.2 (2.92)	Early March
Age ≤24	6.66 (0.232)	0.27 (0.328)	201.0 (70.90)	July
Age 25-44	7.54 (0.104)	0.06 (0.147)	87.1 (11.56)	March
Age 45-64	52.02 (1.060)	2.96 (0.150)	64.2 (29.10)	Early March
Age ≥65	303.75 (2.050)	46.50 (2.900)*	60.9 (3.58)	Early March
Neoplasm				
Total	12.76 (0.072)	0.24 (0.102)	17.9 (24.54)	January
Male	13.65 (0.190)	0.43 (0.268)	48.5 (35.51)	February
Female	9.87 (0.053)	0.14 (0.075)	11.3 (30.07)	January
Age ≤24	0.07 (0.023)	0.01 (0.032)	140.0 (156.0)	April
Age 25-44	2.79 (0.033)	0.03 (0.047)	46.2 (78.26)	February
Age 45-64	22.83 (0.302)	0.45 (0.427)	350.0 (54.02)	December
Age ≥65	78.20 (0.501)	1.86 (0.709)	10.7 (21.81)	January
Circulatory				
Total	11.59 (0.063)	2.38 (0.090)*	57.4 (2.17)	February
Male	11.61 (0.037)	2.33 (0.095)*	54.2 (2.33)	February
Female	11.57 (0.076)	2.44 (0.107)*	61.3 (2.52)	Early March
Age ≤24	0.31 (0.013)	0.03 (0.018)	64.9 (36.20)	Early March
Age 25-44	0.86 (0.017)	0.03 (0.024)	79.1 (44.21)	March
Age 45-64	11.90 (0.306)	1.77 (0.433)*	60.2 (11.43)	Early March
Age ≥65	100.00 (0.890)	22.80 (1.260)*	57.9 (3.17)	February
IHD				
Total	4.11 (0.034)	0.86 (0.048)*	52.8 (3.25)	February
Male	4.44 (0.043)	0.90 (0.061)*	50.3 (3.85)	February
Female	3.79 (0.034)	0.81 (0.048)*	55.8 (3.42)	February
Age 45-64	3.92 (0.083)	0.58 (0.117)*	55.4 (11.60)	February
Age ≥65	36.50 (0.302)	8.20 (0.427)*	52.3 (2.98)	February
CVD				
Total	4.47 (0.033)	0.79 (0.047)*	61.0 (3.45)	Early March
Male	4.23 (0.032)	0.74 (0.045)*	55.2 (3.44)	February
Female	4.73 (0.046)	0.83 (0.065)	68.9 (4.46)	Early March
Age 45-64	4.77 (0.143)	0.62 (0.202)	49.9 (18.61)	February
Age ≥65	39.03 (0.483)	7.89 (0.683)	64.6 (4.96)	Early March
Respiratory				
Total	7.22 (0.069)	1.40 (0.099)*	76.6 (4.05)	March
Male	8.26 (0.091)	1.61 (0.128)*	72.1 (4.57)	March
Female	6.19 (0.061)	1.20 (0.086)*	83.0 (4.10)	March
Age ≤24	0.54 (0.026)	0.11 (0.036)*	105.0 (19.12)	Early April
Age 25-44	0.42 (0.014)	0.06 (0.019)*	96.5 (18.82)	Early April
Age 45-64	5.17 (0.151)	0.86 (0.213)*	81.8 (14.20)	March
Age ≥65	65.5 (0.673)	13.70 (0.951)*	73.8 (3.98)	March

* $p<0.05$, amplitude of the fitted cosine function statistically different from zero
Mesor=average of time series data, expressed in number of death per 100,000 population
SE=standard error