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Seasonality of disease in Kuwait

A. S. DOUGLAS H. AL-SAYER J. M. RAWLES T. M. ALLAN

To compare the seasonal variation in total mortality and deaths from cardiovascular, respiratory, and malignant disease, data were collected from North-East Scotland (Grampian region) and Kuwait. Seasonal differences were similar, in both timing and degree, for total mortality and deaths from circulatory disease, but were greater in Kuwait for respiratory disease. Peak mortality was during winter in both areas: in Grampian, when the climate is most uncomfortable, and in Kuwait, when the climate is at its most comfortable. Socioeconomic changes in Kuwait have been accompanied by a rapid fall in the degree of seasonality (deseasonality) for both total and infant mortality. These findings suggest that mortality peaks in winter, not because of a seasonally low temperature, but because of a seasonal fall in mean temperature irrespective of the annual mean temperature.

Lancet 1991; **337:** 1393–97.

Introduction

The improvements in hygiene, living standards, health care, and medical facilities in Kuwait now allow for comparisons of the seasonality of disease to be made between two northern hemisphere countries with very different climates. Kuwait is at latitude 30° North, and the Grampian region of Scotland lies at 57° North. The seasonality of mortality in Grampian has been studied by us, recorded separately,[1] and is outlined here for comparison with Kuwait. Over 60% of deaths in Grampian are due to cardiovascular and respiratory disease (CVRD), while about 20% are attributable to malignant disease, and the remainder are caused by all other diseases (AOD) and by injuries and poisoning (IP). Seasonality exists for CVRD, AOD, and IP but not for malignant disease.

Materials and methods

Kuwait 1981–84; 1986–88

Monthly mortality data were obtained from the Ministry of Public Health and from the Ministry of Planning in Kuwait. For the years 1981–84, data were provided as a 56-item basic tabulation list, and for 1986–88 were based on the International Classification of Diseases 9th revision. For a comparison between infant and adult deaths, data were taken from United Nations Demographic Yearbooks 1974, 1979, and 1985.[2]

Scotland (Grampian) 1974–88

Mortality data were compiled by the Registrar General and obtained from the Department of Community Medicine, University of Aberdeen.

Climatic data

For Kuwait, data were obtained for the years 1955–73.[3] For two weather stations in Aberdeen, Scotland, data were taken from the thirty years Meteorological Office records (UK) for 1960 (Dyce)[4] and 1982 (Craibstone).[5] Photoperiods were obtained from the Nautical Almanac.[6]

Analysis

Cosinor analysis was applied to assess seasonality.[7] This technique is reliable provided data fit a unimodal sinusoidal curve; the best fit of a cosine-function curve to annual data is then calculated. In 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 to December (345 degrees). Multiple regression analysis is completed between monthly data and sin (t) and cos (t). This analysis gives the multiple correlation coefficient (r), its statistical significance (p), and the angular position in the year (converted to the nearest month) where the fitted sinusoidal regression line has its highest value.

We calculated the mean value per month, M, which 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, A, was measured as the percentage above the mean for the month of highest value (the acrophase). The terms acrophase, zenith, and peak are used synonymously. With this method the nadir comes six months after the acrophase. Significance refers to the presence or absence of seasonality. The cosinor analysis established the 95% confidence limits, but to keep the illustrations as simple as possible they have been shown only in fig 1. The r value of the cosinor analysis gives a guide to the level of significance.

Results

Climate

Temperature differences are shown in fig 1. The July reading in Aberdeen is similar to January in Kuwait. The

ADDRESSES: **Department of Medicine and Therapeutics** (Prof A. S. Douglas, DSc, J. M. Rawles, FRCP), **University of Aberdeen, UK; Faculty of Medicine** (H. Al-Sayer, FRCS), **University of Kuwait, Kuwait; Wellcome Library** (T. M. Allan, MB), **Medical School, University of Aberdeen.** Correspondence to Prof A. S. Douglas, University Department of Medicine and Therapeutics, Medical School, Polwarth Building, Foresterhill, Aberdeen AB9 2ZB, UK.

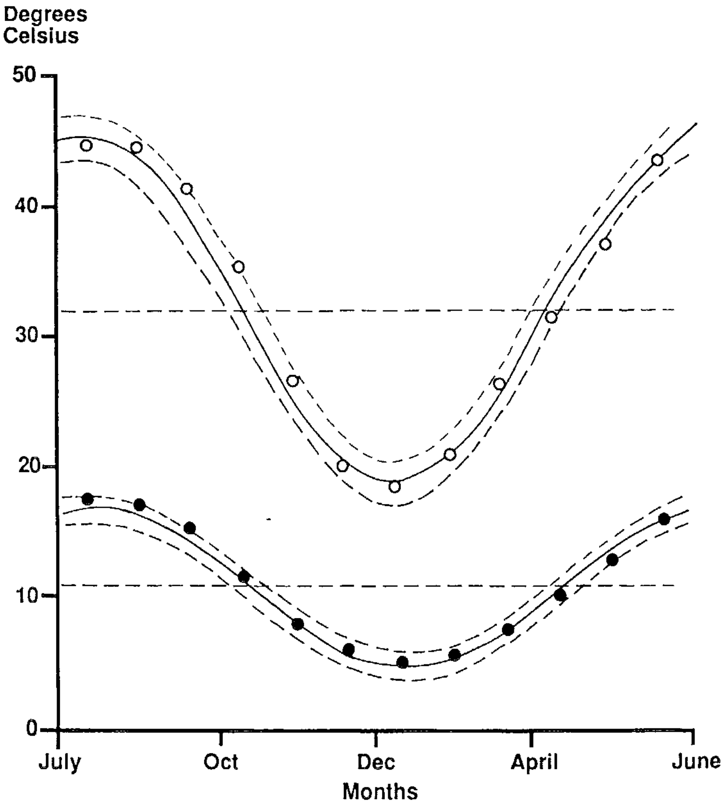

Fig 1—Average maximum daily temperature.

Results of cosinor analysis were: Kuwait (—O—), r=0·99 (p<0·001), amplitude 41·5%, mean 32°C; Grampian (—●—), r=0·98 (p<0·001), amplitude 55·5%, mean 10°C Seasonal fluctuation around the mean between winter and summer is greater in Grampian than Kuwait. 95% confidence limits are shown.

approximate mean maximum daily temperatures in July are 45°C (Kuwait) and 18°C (Aberdeen), and in January are 18°C (Kuwait) and 8°C (Aberdeen). Approximate mean minimum daily temperatures in July are 28°C (Kuwait) and 9°C (Aberdeen), and in January are 8°C (Kuwait) and 0°C (Aberdeen).

There is no rainfall in Kuwait during July and August, and only 17 mm as a monthly average for December and January. Haze mist and fog are common at this time. In July, suspended dust, rising dust, and sandstorms are often seen. The summer months in Kuwait are hot, rainless, and are accompanied by sandstorms but no fog. The hot air can hold much moisture. Heavy work in the late summer and early autumn has to be discontinued because of discomfort. The temperature can rise to 50°C. December through to March are the most comfortable months; it is cooler and sandstorms are rare. Fog can be found, but causes little difficulty.

From the Nautical Almanac, the day-length (photoperiod) was established and its seasonal fluctuation in the northern hemisphere recorded at 30° and 60° latitude; these latitudes are close to Kuwait and Aberdeen, respectively. The cosinor analysis amplitude at 30° was 16·1% and at 60° was 52·5%, which reflected the much greater fluctuation in day length in Grampian compared with Kuwait.

Seasonality of total disease

The populations of Kuwait and Grampian are 1·5 million and 0·5 million people, respectively. The numbers of deaths in Kuwait between 1981–84 and 1986–88 were 32 520 and in Grampian between 1974–88 were 92 208. Male deaths in Kuwait are almost twice as frequent as female deaths because of the large male non-Kuwaiti workforce from other countries. Cosinor analysis of data from Kuwait compared with Grampian is given in the table and figs 2, 3, 4, and 5.

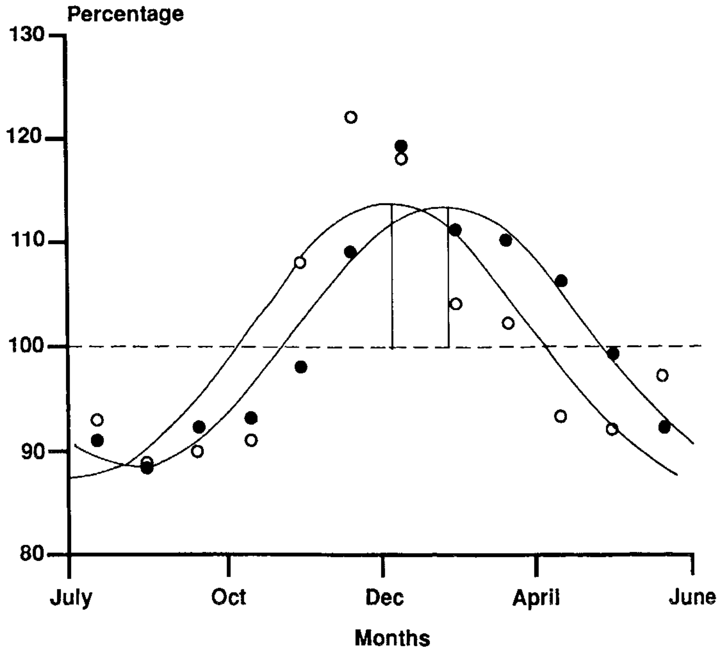

Fig 2—Mortality.

Monthly data for all deaths are expressed as a percentage of the mean monthly value. Although amplitudes (vertical lines from peak to mean) are similar, the zenith for Kuwait is in December, and for Grampian is in January. —O—, Kuwait; —●—, Grampian

For total mortality, there is winter-peak seasonality in Kuwait similar in amplitude to that in Grampian (fig 2). Cosinor analysis of United Nations data[2] on total deaths showed that the amplitude of seasonal fluctuation decreased from about 20% in the mid-1970s to about 10% in the mid-1980s. The composition of death in Kuwait is different from that in Grampian (table). In Grampian, about 60% of total mortality is due to CVRD and is seasonal. The 21% due to malignant disease is non-seasonal. The remaining 17% (AOD and IP) is seasonal. In Kuwait, about 40% of deaths are from CVRD and these are seasonal; about 10% are due to malignant disease, but without seasonality. Deaths from AOD and IP (about 50%) are not seasonal.

For total and cardiovascular mortality, the seasonality is similar in Kuwait and Grampian both in timing and amplitude (table; figs 2 and 3). The acrophase for total

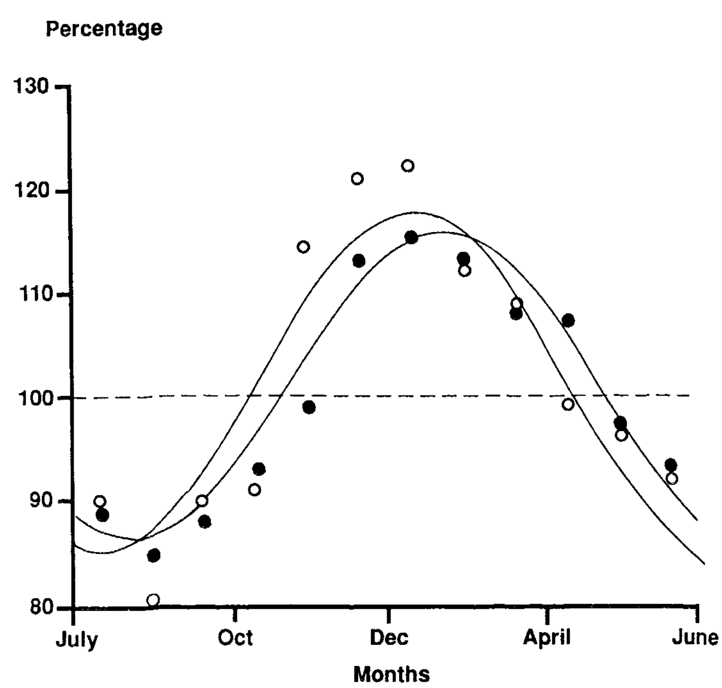

Fig 3—Ischaemic heart disease mortality.

Monthly data for ICD 410–414 expressed as a percentage of the mean monthly value. See table, item 16. —O—, Kuwait; —●—, Grampian

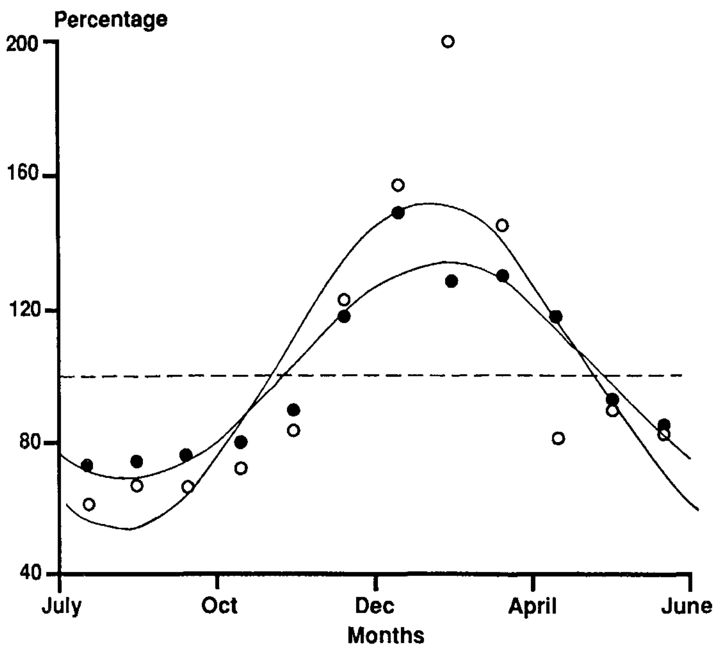

Fig 4—Respiratory disease mortality.

Monthly data expressed as a percentage of the mean monthly value. See table, item 19. —○—, Kuwait; —●—, Grampian.

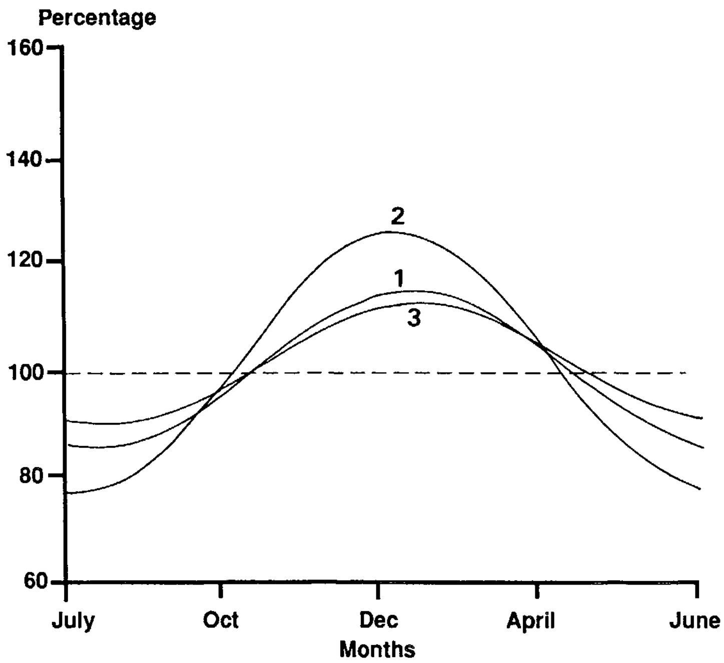

Fig 5—Infant and total mortality.

1, Total mortality ($r=0{\cdot}87$, $p<0{\cdot}01$, amplitude 14·1, mean 1209); 2, infant mortality ($r=0{\cdot}89$, $p<0{\cdot}001$, amplitude 24·7, mean 299); and 3, total minus infant mortality ($r=0{\cdot}81$, $p<0{\cdot}01$, amplitude 10·7, mean 910). The high amplitude for infant mortality has only a small influence on total death.

deaths in Kuwait is in January, while in Grampian it is in February; the nadirs are six months later in July and August for Kuwait and Scotland, respectively. This result is similar to that for coronary disease. Acrophase changes should be viewed with caution and only as trends when examined against the 95% confidence limits of the cosinor analysis.

For respiratory disease (fig 4), the timing of the acrophases is the same (February) in both locations, but the amplitude is almost one-third greater in Kuwait (46% compared with 33%).

COSINOR ANALYSIS OF MORTALITY DATA

					KUWAIT 1981–84: 1986–88					GRAMPIAN 1974–88				
						Cosinor analysis					Cosinor analysis			
ICD	Item	ICD section	ICD Code	Disease category	% total mortality	r	p	Amplitude	Peak month	% total mort-ality	r	p	Amplitude	Peak month
Major groupings	1	VII, VIII		Cardiovascular/ respiratory disease	37	0·85	<0·01	19·6	Jan	62	0·92	<0·001	16·6	Feb
	2	II		Malignant disease	11	0·38	>0·05	3·1	—	21	0·65	>0·05	2·2	—
	3	All others		All other diseases; injury/poisonings	52	0·68	>0·05	10·6	—	17	0·84	<0·01	8·7	Feb
Individual sections	4	I		Infections/parasitic disease	5	0·74	<0·05	28·8	Jan	<1	0·51	>0·05	14·9	—
	5	II		Malignant disease	11	0·38	>0·05	3·1	—	21	0·65	>0·05	2·2	—
	6	III		Endocrine, nutritional, metabolic, immunity										
	7	IV		Blood										
	8	V		Mental										
	9	VI		Neurological										
	10	IX		Digestive	10	0·58	>0·05	10·8	—	9	0·84	<0·01	11·4	Feb
	11	X		Genito-urinary										
	12	XI		Obstetric										
	13	XII		Dermatological										
	14	XIII		Musculoskeletal										
	15	VII		Circulatory	29	0·84	<0·01	14·8	Jan	52	0·96	<0·001	14·3	Feb
	16		410–414	Coronary	(13)	0·89	<0·001	15·4	Jan	29	0·95	<0·001	14·7	Feb
	17		430–438	Cerebrovascular	(2)	0·42	>0·05	10·7	—	15	0·93	<0·001	13·3	Feb
	18			Other	(14)	0·74	<0·05	14·9	Jan	8	0·96	<0·001	15·0	Feb
	19	VIII		Respiratory	8	0·83	<0·01	45·7	Jan–Feb	10	0·95	<0·001	32·5	Feb
	20	XIV		Congenital anomalies	7	0·81	<0·01	18·2	Dec	<1	0·41	>0·05	7·3	—
	21	XV		Perinatal	9	0·26	>0·05	2·5	—	<1	0·47	>0·05	15·0	—
	22	XVI		Symptoms, signs, and ill-defined conditions	6	0·51	>0·05	19·1	—	<1	0·78	<0·05	27·3	Jan
	23	XVII		Injury/poisoning	15	0·34	>0·05	3·0	—	6	0·77	<0·05	6·2	Dec
				Total	100	0·8	<0·01	12·8	Jan	100	0·96	<0·001	12·4	Feb

ICD = International Classification of Diseases

There was no seasonality for malignant disease in either country. The comparison of diseases that contribute to all other deaths differs numerically between the two areas and makes comparison more difficult. In Grampian, this group constitutes 17% of the total, whereas in Kuwait it is 52% (table). One method of making a comparison is by grouping. Infectious and parasitic disease (item 4), congenital anomalies (item 20), perinatal conditions (item 21), and symptoms, signs, and ill-defined conditions (item 22) make up 27% of deaths in Kuwait, while in Grampian they account for less than 2%. For item 4 and item 20, significant winter peak seasonality was found in Kuwait. Items 6–14 were responsible for 10% and 9% of mortality in Kuwait and Grampian, respectively. Injuries (item 23) caused 15% and 6% of deaths in Kuwait and Grampian, respectively. Significant seasonality was found for items 6–14 and 23 in Grampian, but not in Kuwait.

Seasonality of infant death

The contribution of age to seasonality of mortality differs between Kuwait and Scotland. In Kuwait (1980–83), 24·7% of deaths were among infants, while in Scotland this proportion was much smaller (< 1%). In Grampian, deaths among those over 75 years of age constitute 48% of deaths, while in Kuwait they account for only 24% of deaths.[1]

Our data show much greater seasonality among the elderly in Grampian.[1] In Kuwait, the seasonal fluctuation among infants is twice that in all other age groups (fig 5). The contribution of infant deaths (with greater seasonality) to the total seasonality is small. From 1985 World Health Organisation Demographic Year Book data,[2] the amplitude of infant mortality fell from 38·7% in 1976 to 18·7% in 1983, with the total number of deaths falling in these same years by a third. In Kuwait between 1976 and 1983, the amplitude of infant mortality was about 30%, whereas in Scotland it was about 10%.[2]

Discussion

We recognise the limitations of death certification, but believe that our conclusions are probably justified because of the wide disease groupings analysed. Cosinor analysis is a standard method in statistics and quantitative epidemiology. In our study, we have applied this technique to measure seasonality. Statisticians call this method Fourier analysis and here the period has been limited to one year.[8,9]

Sakamoto-Momiyama has described "deseasonality" of disease in Japan.[10] As Japan progressed from 1899 to a modern developed country, the pattern of seasonality of mortality changed. In 1899, there were two peaks: a small one in the winter, and a much larger one in the summer. Around 1930 these two peaks were of about equal size. By the 1960s the summer peak had grown smaller and been lost, while the winter peak became larger. When there was only a single winter peak, its amplitude then fell. Deseasonality is used here to refer to the evolution of these changes from the end of the last century. The environmental influences of latitude, and continental and maritime climates may influence amplitude of mortality.[11] Data from the United Nations Demographic Yearbook, 1985, show a peak in Egypt during the summer, with a minor peak in winter as in Japan in 1899.

Deseasonality is caused by socioeconomic changes such as improved public health and medical care. As the process evolves, death from ageing and CVRD accumulate during the winter while the frequency of infections declines during the summer. This view may be too simplistic; some older people could be part of the summer peak.

Kuwait has developed rapidly. Infant mortality has fallen from 35 per 1000 livebirths in 1976, to 20 per 1000 in 1983. The corresponding figures in Egypt and the UK are approximately 70 per 1000 and 10 per 1000, respectively. In countries with a total mortality summer peak, a reduction in infant deaths contributes to the progress of deseasonality. In northern mainland Europe, the change from deseasonality was complete in the early nineteenth century.[12] Sakamoto-Momiyama found that an obvious winter peak did not become clear in England and Wales until towards the end of the nineteenth century.[10] Despite socioeconomic changes in Kuwait, there may still be a trace of deseasonality that has prevented the cosinor analysis from providing a significant single sinusoidal curve in all sections, where one is present in Grampian. The finding that total mortality is significant for a single winter peak in Kuwait suggests that the evolution is close to completion. Cosinor analysis is most reliable when both the numbers and amplitude are large. For Grampian, all sections (table; items 1–4) revealed seasonal significance except malignant disease. A low amplitude for cancer has been reported by others who have been able to study large numbers of people from national statistics.[13]

Kuwait has the seasonal timing of the developed countries of the northern hemisphere for total, circulatory, and respiratory diseases. As in Grampian, malignant disease is not seasonal. When CVRD and malignant disease are excluded from the total, seasonality is a feature of all other diseases in Scotland, but not in Kuwait. The remainder of deaths in Kuwait show a non-significant trend towards seasonality ($r = 0{\cdot}68$). Total mortality in Kuwait is seasonal and when the process of deseasonality is completed, Kuwait's figures may be the same as those of Grampian. The June, July, and August figures for Kuwait suggest the existence of an old summer peak.

In Grampian, 52% of all deaths are due to cardiovascular disease with the typical winter peak. In the USA, the lowest number of deaths in colder areas was associated with temperatures of 15–26°C.[14] In warmer areas, the lowest mortality was associated with higher temperatures, such as 26–32°C in Miami. However, in New York, Chicago, and St Louis, temperatures of 32°C in the summer were associated with a rise in deaths. These American cities have atypical environmental features; the shape of their mortality curve was not reproduced in states with a warmer winter such as Florida. No summer peak was seen for deaths from ischaemic heart disease, although in the summer Kuwait is among the hottest places in the world. Anderson and Le Riche reported a lower amplitude for coronary mortality in colder areas of Canada compared with England.[15] We found the same amplitude for coronary death in Scotland and Kuwait, where there is a much milder winter and a very hot summer.

Physiological variables have been found to match seasonality of cardiovascular mortality, and may offer an explanation of these findings. Platelet serotonin concentrations and uptake sites have seasonal changes,[16,17] and fibrinolysis is more active in summer compared with winter.[18] Packed cell volume and white cell counts are increased in winter[19] and haemodynamic changes also take place.[20] We found seasonal variation to be greatest for respiratory death, especially in Kuwait. The exposure of the alveolar surface area (about 140 m^2) to the environment may explain how the environment leads to a winter peak for total mortality.

We have shown how rapid improvements in socioeconomic conditions can lower amplitude of seasonality of mortality. Our findings confirm those for the seasonality of births.[21]

In the southern hemisphere, a mortality peak exists around July during the winter months.[22] Seasonal climatic change must have an important influence. The importance of the photoperiod in the study of human seasonality is increasingly recognised—eg, in seasonal affective disorder and in seasonality of birth. Human beings possess a circadian clock that is affected by photoperiod. Alteration of this clock by the daily photoperiod may create seasonal patterns that give the appearance of a circannual clock. Photoperiod helps to keep the clock to time. The amplitude of the seasonal fluctuation of day length is more than three times greater in Grampian than in Kuwait. Photoperiod may entrain circadian and circannual rhythms, which in turn are altered by climatic and socioeconomic variables. This work was in progress before the Iraqi invasion of Kuwait in August, 1990, which prevented amplification of some of our data.

We thank the Ministry of Public Health, the Ministry of Planning, Mr Mustafa M. Mustafa (Chairman of the Statistics Division), Kuwait, and the Department of Community Medicine, University of Aberdeen. A. S. D. held a Leverhulme senior emeritus research fellowship. We also thank Mrs M. Burnett for secretarial assistance, the University of Aberdeen Medical School Library, and the Department of Medical Illustration.

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PUBLIC HEALTH

Improving the cost-effectiveness of AIDS health care in San Juan, Puerto Rico

YAMIL H. KOURI DONALD S. SHEPARD FREDDIE BORRAS
JEANNETTE SOTOMAYOR GEORGE A. GELLERT

In an era of decreasing availability of funds and increasing demand, the AIDS epidemic threatens to overwhelm health-care services in some countries. We describe a comprehensive model for the treatment of AIDS in San Juan, Puerto Rico, and compare it with traditional hospital-based services. Given the existing allocation of funds, the comprehensive model emphasised prevention, education, surveillance, early detection, and outpatient care to reduce hospital care. In 1987, the last year of the traditional system, there were 95 admissions of AIDS patients to hospital, and in 1988, the first year of the comprehensive model, there were 100 admissions. The mean length of stay of AIDS inpatients was reduced from 22·3 days in 1987 to 11·3 days in 1988, a 46·8% reduction ($p=0·001$). The annual mean (SE) cost of inpatient care per AIDS patient fell from $15 118 (1699) in 1987 to $3869 (659) in 1988. Savings were used to improve non-hospital services, including outreach, education, emergency and outpatient care, laboratory and epidemiological services, and research, and to introduce an employee incentive scheme. Management strategies that reduce the length of inpatient care and provide less costly treatment alternatives can improve AIDS health care in developing nations.

Lancet 1991; **337:** 1397–99.

ADDRESSES: **Harvard Institute for International Development, Harvard University, 1 Eliot Street, Cambridge, Massachusetts 02138, USA** (Y H. Kouri, MD, DrPH, D. S. Shepard, PhD, G. A. Gellert, MDCM, MPH); **and San Juan City Department of Health** (F. Borras, MD), **and Suan Juan AIDS Institute** (J. Sotomayor, MPH), **San Juan, Puerto Rico.** Correspondence to Dr Y H. Kouri.