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Seasonal distribution of mortality in Barcelona (1983-1985)

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RESUMO

Analisou-se a distribuição mensal da mortalidade por causa e sexo na cidade de Barcelona durante o período de 1983-1985.

Pela aplicação do método de Edwards, verificou-se a tendência cíclica, segundo um modelo de variação harmónica simples em nove causas de óbito (endócrinas, nutricionais e metabólicas; doenças mentais; sistema nervoso e órgãos dos sentidos; aparelho circulatório; aparelho respiratório; aparelho digestivo; aparelho genito-urinário, causas perinatais; causas mal definidas), afastando-se deste modelo de mortalidade sazonal outras seis causas (infecciosas e parasitárias; tumores; sangue e órgãos hematoréticos; sistema osteo-muscular; anomalias congénitas; traumatismos e envenenamentos).

De acordo com o modelo teórico, na cidade de Barcelona, o máximo de mortalidade ocorre no princípio de Fevereiro e o mínimo no princípio de Agosto.

Palavras-chave: Mortalidade; Sazonalidade; Modelo de variação harmónica simples.

ABSTRACT

We have analyzed the monthly mortality distribution according to causes of death and sex during the period 1983-85 in the city of Barcelona.

Using Edwards' method we haved checked the cyclic trend according to a model of simple armonic variation in nine causes of death (endocrine; nutritional and metabolic; mental disorders; nervous system and sense organs; circulatory system; respiratory system; digestive system; genito-urinary system; perinatal; ill-defined diseases), rejecting the seasonal mortality model in a further six cases (infective and parasitic; neoplasms; blood and blood forming organs; musculo-skeletal system, congenital anomalies; accidents, poisonings and violence).

According to the theoretical model, in the city of Barcelona, the maximum occurs at the beginning of February and the minimum at the beginning of August.

Key-words: Mortality; Seasonality; Simple harmonic variation pattern.

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INTRODUCTION

The study of the seasonal distribution of mortality is of interest in order to find out its incidence during a certain period and also to analyze its evolution through that period together with biological, cultural and social changes occurring in the population.

Seasonal variations in mortality according to the different causes of death may be of use to understand the changes arising in the relationship between the population and its environment, and are helpful in determining biological evolution in human groups. Unfortunately it is not always possible to reconstruct seasonal distribution according to the causes of death during a stipulated period as there is no reliable way of dealing with the causes on a systematic basis.

In addition to biodemographic interest, knowledge of the seasonal distribution of mortality is of evident use when related to cyclic climatic variations and the evolution of environmental conditions. Together with knowledge of the etiology of each disease, it can help to improve health planning measures and the organisation of preventive medicine.

In this paper we have analyzed seasonal distribution according to causes of death in the city of Barcelona (Catalonia, Spain) during the past three years. Practical interest is centred on establishing in which cases seasonal distribution can be adapted to the theoretical distribution of a simple harmonic variation.

MATERIAL AND METHODS

From the data published in the Journal «Gaseta Sanitária» (numbers 9 to 26) by the municipal authorithy of Barcelona, we have studied the seasonal distribution of the deaths of persons resident in the city of Barcelona during the three year period 1983-1985.

An anlyses was made for each year according to causes of death and sex, and the total number of deaths in the three years was grouped together by months in order to increase the size of the sample.

Monthly distribution was evaluated by means of the seasonal coefficient (HENRY, 1972).

We followed the method proposed by Edwards to analyze whether the monthly distribution adapts to a simple harmonic variation (EDWARDS, 1961).

Edwards considered that Pearson X^2 method is a bad test for detecting a cyclic trend because «of the (n-1) D.F. only one or two are likely to be necessary to specify any biologically meaningful type of trend, and the remaining (n-2) or (n-3) will produce a cloud of uncertainty.»

For the recognition and estimation of cyclic trends Edwards presented the data in a circle divided into 12 sectors corresponding to 12 months. In each sector we will have the number of deaths observed. In the absence of any cyclic trend the expected centre of gravity will be at the centre of the circle. The distance (d) of the centre of gravity from the centre of circle will have a probability distribution on the null hypothesis.

Considering the simple harmonic cyclic trend, in which the frequency is proportional to $1 + a \sin \theta$, we will have 12 weights at directions $\theta_i = 2\pi\, i/12$ from the origin and at respective distances $r_i = \sqrt{(1 + a \sin \theta_i)}$ $(i = 1,..., 12)$.

If d is the distance of the centre of gravity of these weights from the origin, we will have: $a = 4d$; $\mathrm{var}\, a = 2/N$.

We can obtain: $S = \Sigma \sqrt{N_i} \sin \theta_i$; $C = \Sigma \sqrt{N_i} \cos \theta_i$; $W = \Sigma \sqrt{N_i}$; $d = \sqrt{(S^2 + C^2)}/W$.

On the null hypothesis $1/2\ NA^2$ is distributed as a X^2 with 2 D.F.

The maximum will be $\theta = (\mathrm{than}^{-1}\ S/C) + 15^o$ in a simple harmonic variation.

Taking into account the size of the sample studied in the present case, we can discard James' objection to the method used by Edwards (JAMES, 1980).

There being no excessively hard winters during the period studied nor any epidemics or other execptional factors, the results will reflect the seasonal mortality trend in Barcelona at the present time.

RESULTS AND COMMENTS

Table 1 shows the mortality distribution in Barcelona between 1983 and 1985 according to causes of death. It can be seen that the main cause of death is from circulatory diseases (44.3%) followed by tumours (27%), respiratory diseases (7.3%) and digestive diseases (6.9%).

There are differences in the incidence of the various causes of death in both sexes. Women are more affected by circulatory, endocrine, nutritional and metabolic diseases than men. But men more frequently die from tumours, respiratory diseases and digestive aliments and from trauma and poisoning.

If we compare the results in Barcelona for 1984 with those for the whole of Catalonia in the same year (C.I.D.C., 1986), we observe more deaths from tumours in Barcelona and less deaths in that city from circulatory diseases, trauma and poisoning. This same tendency is observed when comparing their incidence in whole of Spain in 1974 (W.H.O., 1977).

When studying seasonal distribution, considering all causes of death conjunctly, we obtain the coefficients appearing in Table 2 (see Fig. 1). We note a tendency to minimum mortality in the months of August and September, while maximum values appear in the coldest months of January and February. The increase in mortality in the month of July must be noted, compared with the imediately preceding and succeeding months in 1983 and 1985. The figure for 1984 clearly shows that the year is divided into two halves as regards seasonal mortality distribution.

Figure 2 shows the coefficients obtained when taking the results from the three years into account. If we compare the results from both sexes separately we can appreciate no relevant differences in seasonal tendencies.

TABLE 1. *Mortality according to cause in Barcelona (1983-85), Catalonia (1984) and Spain (1974)*

	Barcelona (1983-85)						Catalonia 1984		Spain (1974)
	Male	%	Female	%	Total	%	Total	%	%
I. Infective and parasitic disease (A1-A44)	221	1.0	133	0.6	344	0.8	398	0.9	2.0
II. Neoplasms (A45-A61)	6817	31.0	5073	23.0	11890	27.0	11093	25.1	17.3
III. Endocrine, nutritional and metabolic diseases (A62-A66)	486	2.2	805	3.6	1291	2.9	1375	3.1	2.5
IV. Dis. of blood an blood-forming organs (A67-A68)	83	0.4	82	0.4	165	0.4	161	0.4	0.3
V. Mental disorders (A69-A71)	171	0.8	277	1.3	448	1.0	425	1.0	0.3
VI. Dis. of the nervous system and sense organs (A72-A79)	225	1.0	254	1.1	479	1.1	547	1.2	1.3
VII. Diseases of the circulatory system (A80-A88)	8500	38.7	11030	50.0	19530	44.3	19459	44.0	44.2
VIII. Diseases of the respiratory system (A89-A96)	1863	8.5	1361	6.2	3224	7.3	3216	7.3	11.9
IX. Diseases of the digestive system (A97-A104)	1722	7.8	1312	5.9	3034	6.9	2990	6.8	5.5
X. Diseases of genito-urinary system (A105-A111)	552	2.4	497	2.3	1019	2.3	942	2.1	2.1
XI. Complications of pregnancy, chilbirth, etc. A112-A118)	—	0.0	4	0.0	4	0.0	7	0.0	0.1
XII. Dis. of the skin and subcutaneous tissue (A119-A120)	6	0.0	23	0.1	29	0.1	41	0.1	0.1
XIII. Dis. of the musculo-skeletal sys. and connective tissue (A121-A125)	44	0.2	98	0.4	142	0.3	119	0.3	0.2
XIV. Congenital anomalies (A126-A130)	80	0.3	85	0.4	165	0.4	209	0.5	0.8
XV. Certain causes of perinatal mortality (A131-A135)	106	0.5	68	0.3	174	0.4	156	0.4	0.7
XVI. Symptoms and ill-defined conditions (A136-A137)	309	1.4	343	1.6	652	1.5	762	1.7	.5.6
XVII. Accidents, poisonings and violence (AE138-AE150)	835	3.8	609	2.8	1444	3.3	2306	5.2	5.1

TABLE 2. *Seasonality coefficients in Barcelona (1983-85)*

	J	F	M	A	M	J	J	A	S	O	N	D
Male (1983)	132.4	135.9	96.5	108.8	99.9	90.8	99.1	88.5	79.5	87.9	97.7	90.5
Female (1983)	126.5	124.4	106.0	99.9	90.0	85.3	104.6	79.3	101.2	82.8	95.5	104.0
Total (1983)	131.0	131.6	102.5	101.6	96.0	89.1	103.1	84.8	77.0	86.3	97.8	98.5
Male (1984)	111.0	131.7	112.0	100.8	102.4	98.8	89.4	74.7	84.4	87.9	101.2	105.0
Female (1984)	99.7	118.0	124.2	103.2	98.6	94.6	88.7	76.2	85.5	96.6	101.8	113.5
Total (1984)	105.4	124.9	118.0	102.0	100.0	96.7	89.1	75.4	84.9	92.2	101.5	109.2
Male (1985)	135.9	99.5	100.8	89.1	93.5	95.2	103.0	81.4	89.0	87.2	109.2	115.6
Female (1985)	137.2	103.6	105.4	93.0	100.1	93.7	99.7	75.5	79.3	87.5	111.4	112.9
Total (1985)	136.6	101.6	91.1	96.9	94.4	101.3	78.4	84.1	87.4	110.3	114.3	
Male (1983-85)	126.7	122.3	102.9	96.9	98.5	94.8	97.3	81.6	84.2	97.7	102.7	103.7
Female (1983-85)	122.8	116.3	112.4	99.4	96.6	91.8	98.7	77.7	79.7	89.5	103.7	110.9
Total (1983-85)	124.7	119.3	107.7	98.1	97.6	93.3	98.0	79.7	82.0	88.6	103.2	107.3

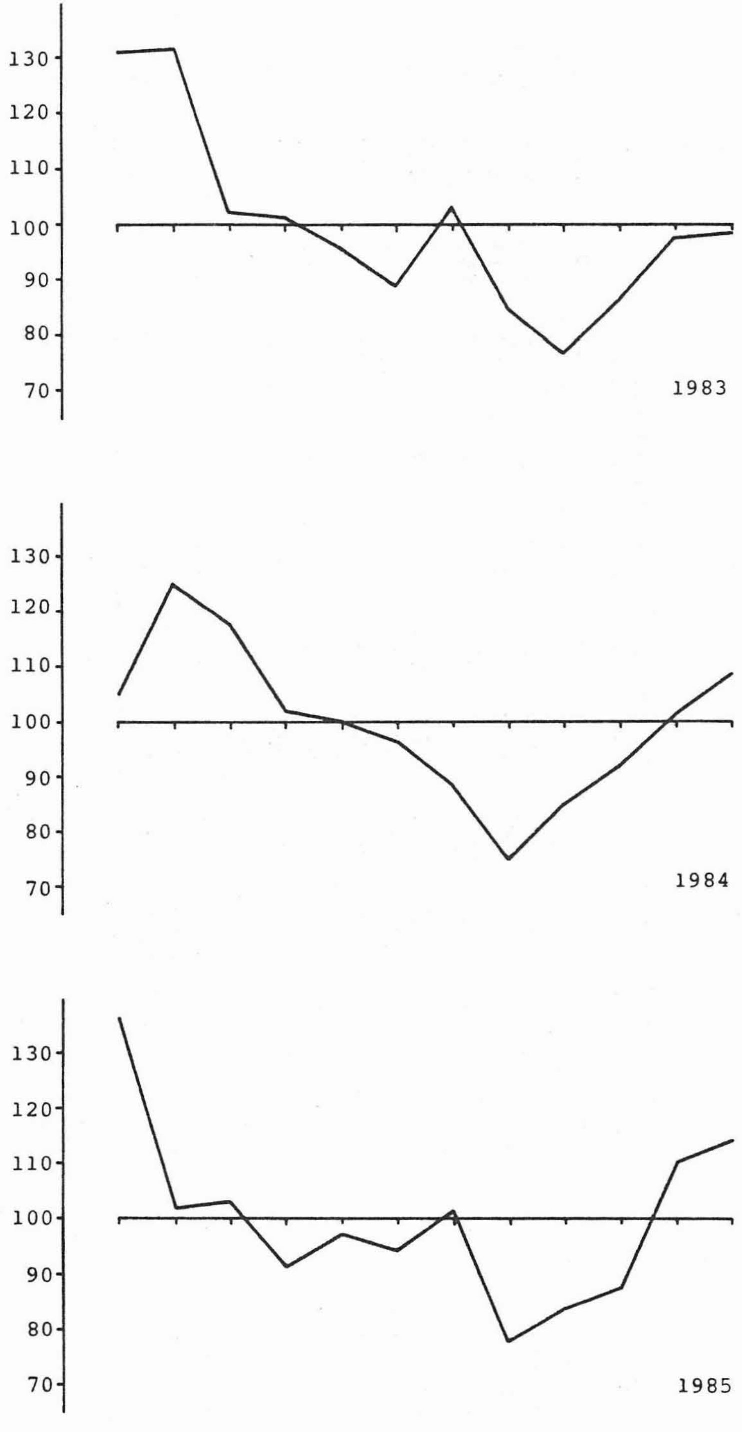

Fig. 1 — Seasonal distribution of mortality in Barcelona

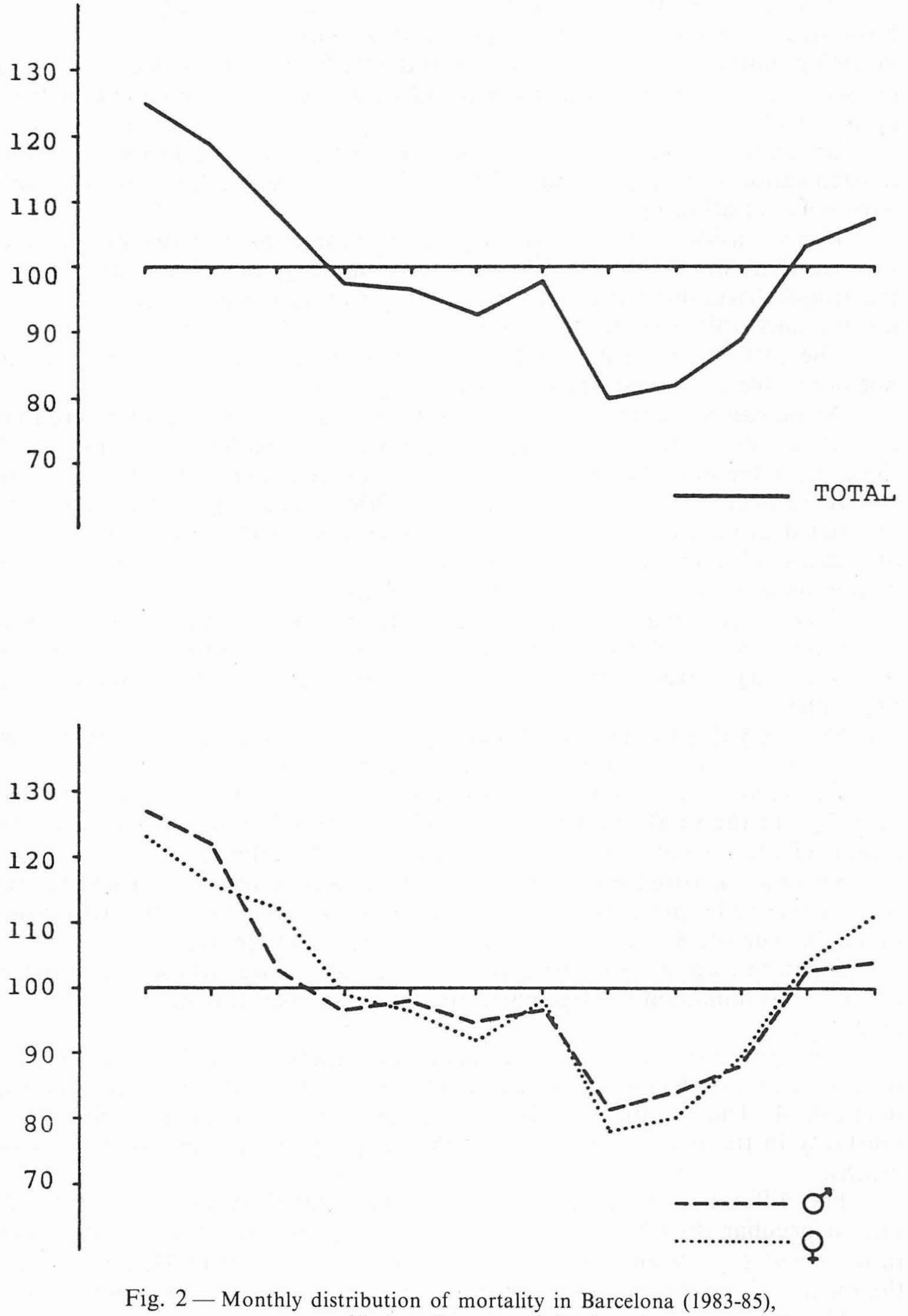

Fig. 2 — Monthly distribution of mortality in Barcelona (1983-85), considering all causes of death

If we take the total mortality results from the three years and consider both sexes together, we obtain the seasonal coefficients on Table 3 when grouping mortality according to cause of death. Figures 3 and 4 are a graphic demonstration of the seasonal tendency of causes of death presentig a relevant cyclic trend.

On Table 4 we have the results for the application of Edwards's method in each cause of death, to study whether the cyclic trend adapts to the simple harmonic variation model.

If we consider seasonal distribution in the five main causes of death we can see that three of these (circulatory, respiratory and digestive) adapt to the simple harmonic variation model, while tumours, trauma and poisoning do not show this seasonal variation.

The cyclic trend of deaths due to pregnancy and diseases of the skin has not been able to be assessed due to their infrequency.

As we can see, apart from tumours, trauma and poisoning, there are four further causes of death which do not follow the seasonal model proposed: these are infections, blood diseases, osteo-muscular and congenital diseases.

If we bear in mind empirical results (Table 3 and Figs. 3 and 4) we can see that death from circulatory diseases is clearly separated into six months of maximum and minimum frequency, January and August having the maximum and minimum frequency respectively.

There is considerable variation in death due to respiratory diseases and these differences and their maximum and minimum seasonal frequency are relatively large. Here the maximum is in February and the minimum in September.

Mortality due to digestive diseases presents a maximum in February and a minimum in October, with a considerable rise in June.

The relative importance of these diseases (circulatory, respiratory, and digestive) in the total number of deaths in the population is reflected in the total cyclic trend presented in the population of Barcelona.

Seasonal distribution of the remaining causes of death adjusting to the theoretical model presents fairly marked monthly oscillations but with minimums in August, September, October, and maximuns in January.

Separate mention must be made of perinatal diseases whose maximum is in April and minimum in December, presenting a seasonal distribution relative to births.

If we now consider the results obtained on applying the theoretical model for each cause of death, we obtain the maximum and minimum values shown in Table 4. The month of February presents the theoretical maximum in mortality in the majority of cases, while August presents the last number of deaths.

The differences noted in the case of perinatal diseases must be stated, due to peculiar distribution of the empirical values already mentioned. The ratio $(1+a)/(1-a)$ found for this cause of death is greater (3.34) and reflects the extent of the difference between the maximum and the minimum values.

This ratio is also relatively high (2.07) in the case of respiratory diseases.

TABLE 3. *Seasonality coefficients according to cause in Barcelona (1983-85)*

	J	F	M	A	M	J	J	A	S	O	N	D
I. Infective and parasitic diseases (A1-A44)	119.4	147.4	95.5	91.7	85.3	91.7	116.0	99.0	81.1	109.2	88.1	75.1
II. Neoplasms (A45-A61)	93.8	133.2	101.0	92.9	106.4	99.0	104.5	90.8	96.6	99.3	104.8	97.1
III. Endocrine, nutricional and metabolic diseases (A62-A66)	140.5	109.0	112.2	88.6	109.4	84.8	102.1	80.2	71.6	90.3	112.1	98.5
IV. Dis. of blood and blood-forming organs (A67-A68)	70.5	140.6	91.7	109.3	77.6	116.6	56.4	127.0	102.0	105.8	138.5.	63.5
V. Mental disorders (A69-A71)	131.2	122.0	112.8	67.8	68.2	84.0	105.0	65.6	103.0	86.6	122.0	131.2
VI. Dis. of the nervous system and sense organs (A72-A79)	145.1	87.1	105.7	96.5	68.8	104.2	110.7	61.5	83.8	76.2	124.5	135.3
VII. Diseases of the circulatory system (A80-A88)	140.0	117.1	112.3	102.4	95.1	89.4	91.8	70.0	76.2	85.0	104.1	116.0
VIII. Diseases of respiratory system (A89-96)	150.4	152.8	124.5	108.7	84.8	70.7	98.7	68.1	61.7	76.8	91.4	110.7
IX. Diseases of the digestive system (A97-A104)	122.3	130.7	105.3	92.8	92.5	102.4	91.0	85.1	86.4	83.2	103.6	104.1
X. Diseases of genito-urinary system (A105-A111)	118.	0155.2	105.2	101.6	89.0	106.4	106.4	100.6	77.7	70.5	92.0	116.8
XI. Complications of pregnancy, childbirth, etc. (A112-A118)	289.8	320.8	0.0	0.0	0.0	0.0	289.8	0.0	299.4	0.0	0.0	0.0
XII. Dis. of the skin and subcutaneous tissue (A119-A120)	81.7	45.2	122.5	84.4	204.2	126.6	122.5	122.5	126.6	122.5	0.0	40.8
XIII. Dis. of the musculo-skeletal sys. and connective tissue (A121-A125)	99.8	55.2	108.1	128.9	133.1	103.1	74.8	66.5	85.9	116.4	94.5	133.1
XIV. Congenital anomalies (A126-A130)	128.3	134.1	106.9	103.1	114.0	88.4	142.5	57.0	81.0	144.0	58.9	71.2
XV. Certain causes of perinatal mortality (A131-A135)	148.7	112.2	108.1	181.6	114.9	118.7	121.6	114.9	55.8	47.3	41.9	33.8
XVI. Symptons and ill-defined conditions (A136-A137)	124.1	153.3	95.3	113.3	84.5	89.2	93.5	111.5	72.4	62.9	111.5	88.1
XVII. Accidents, poisonings and violence (AE138-AE150)	115.8	109.2	79.1	69.9	104.4	110.4	111.7	90.5	88.5	109.3	114.6	96.2

TABLE 4. *Simple harmonic cyclic trend in mortality of Barcelona (1983-85)*

	d	a	var a	χ^2_2	P	θ	maximum	minimum	ratio $\frac{1+a}{1-1a}$
I. Infective and parasitic	0.01396	0.05585	0.0581	0.536	0.80-0.70				
II. Neoplasms	0.00276	0.01104	0.00016	0.724	0.070-0.50				
III. Endocrine, nutricional and metabolic	0.04054	0.16216	0.00154	16.975	<0.001	37.2°	6 February	8 August	1.38
IV. Blood and blood-forming organs	0.01190	0.04761	0.01204	0.188	0.095-0.90				
V. Mental disorders	0.06459	0.25837	0.00446	14.953	<0.001	37.5	7 February	8 August	1.70
VI. Nervous system and sense organs	0.04907	0.19630	0.00417	9.229	0.01-0.001	20.6°	20 January	22 July	1.47
VII. Circulatory system	0.03849	0.15399	0.00010	231.556	<0.001	47.6°	17 February	18 August	1.35
VIII. Respiratory system	0.08817	0.35268	0.00062	200.505	<0.001	43.4°	13 February	14 August	2.07
IX. Digestive system	0.03600	0.14400	0.00065	31.456	<0.001	38.1°	7 February	9 August	1.32
X. Genito-urinary system	0.02810	0.11240	0.00196	6.424	0.05-0.01	52.3°	9 March	7 September	1.25
XI. Pregnancy, childbirth, etc	—	—	—	—	—				
XII. Skin and subcutaneous tissue	—	—	—	—	—				
XIII. Musculo-skeleta system	0.02002	0.08011	0.455	0.80-0.70					
XIV. Congenital anomalies	0.04691	0.18767	0.01212	2.905	0.30-0.20				
XV. Perinatal mortality	0.13451	0.53805	0.01149	25.186	<0.001	89.0°	1 April	29 September	3.34
XVI. Symptoms and ill--defined condictions	0.04320	0.17281	0.00306	9.735	0.01-0.001	54.9°	24 February	26 August	1.41
XVII. Accidents, poisonings and violence	0.01968	0.07873	0.00138	4.472	0.20-0.10				
ALL CAUSES (MALE)	0.03480	0.13921	0.00009	213.599	<0.001	39.0°	8 February	9 August	1.33
ALL CAUSES (FEMALE)	0.04009	0.16038	0.00009	283.696	<0.001	38.9°	8 February	9 August	1.38
ALL CAUSES (TOTAL)	0.03758	0.15032	0.00004	498.221	<0.001	38.9°	8 February	9 August	1.35

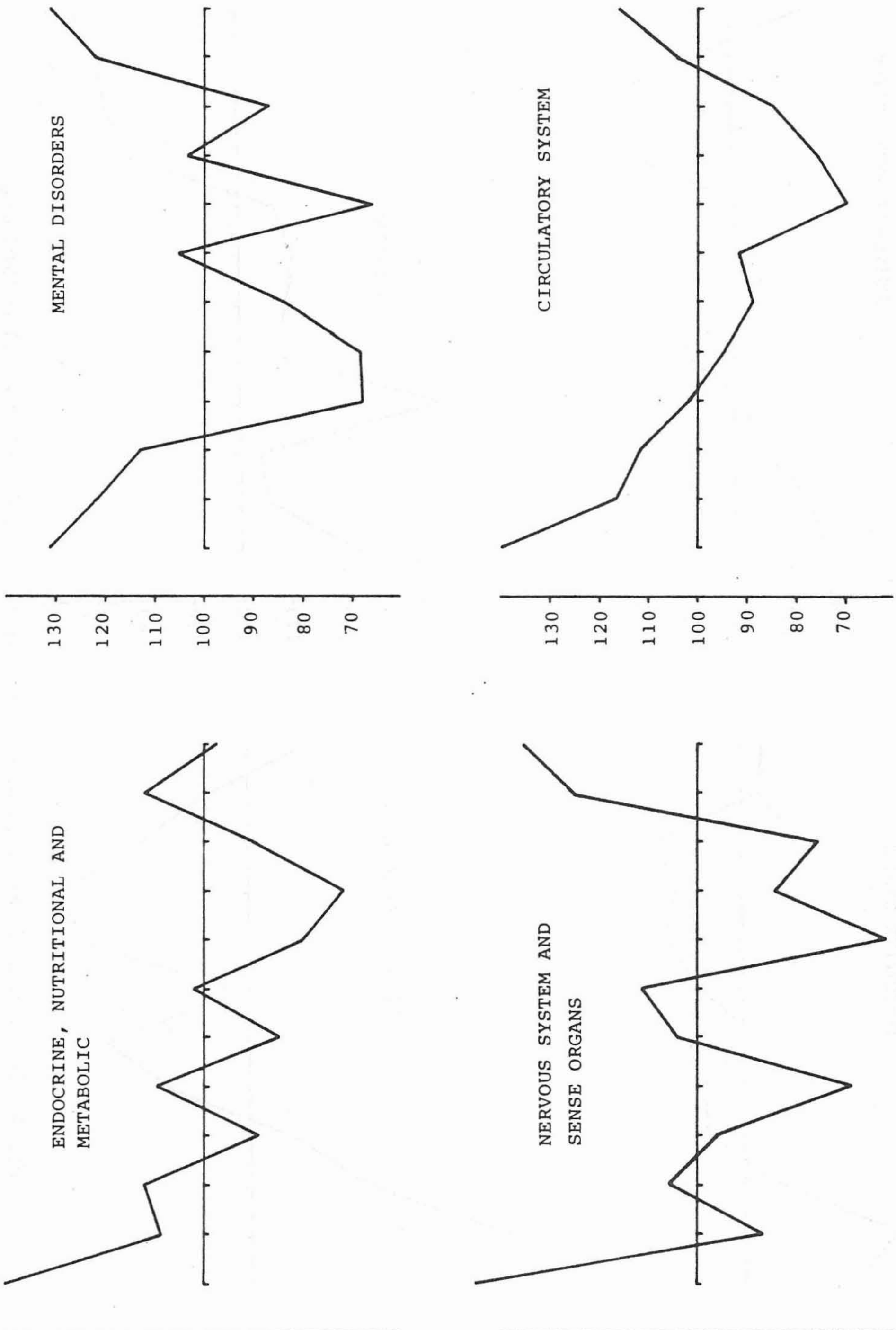

Fig. 3 — Distribution of seasonal coefficients according to causes of death in Barcelona (1983-85)

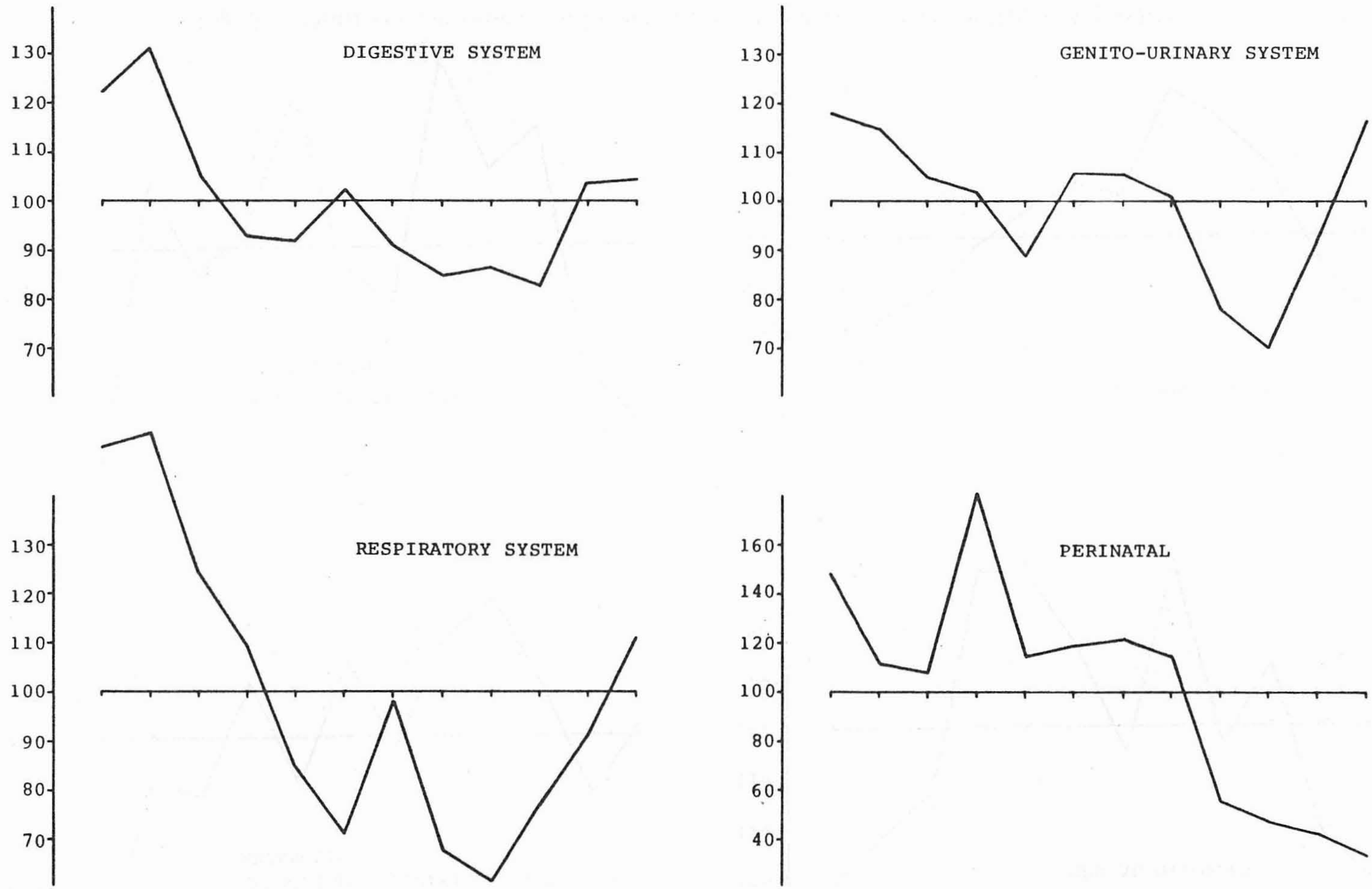

Fig. 4 — Distribution of seasonal coefficients according to causes of death in Barcelona (1983-85)

For the sum total of deaths arising in the three years under study we have obtained a theoretical maximum for the beginning of February and a theoretical minimum for the beginning of August, the ratio between the highest and the lowest incidence being 1.35.

A final comment should be made on the divergencies obtained on evaluating the seasonal trend with Pearsons' X^2 test and Edwards' method. While aleatory differences between one month and another may provide significant differences with regard to null hypothesis using the X^2 test, Edwards' method enables us to assess these monthly differences with regard to the temporal distance intervening.

Thus, for example, we see (Table 4) that by studying the cyclic trend of the sum total of mortality in both sexes separately, with Edwards' method we obtain practically identical theoretical values (with the same days of maximum and minimum). However the X^2 test for the differences in the monthly distribution between both sexes gives results which would imply a significantly different seasonal distribution ($X^2_{11} = 22.754$; $P < 0.05$).

Similarly, if we apply the X^2 test to contrast the null hypothesis in the case of monthly distribution in tumours for example, we note a significant deviation with regard to the theoretical monthly frequencies ($X^2_{11} = 41.191$; $P < 0.01$), but this should not be interpreted as a cyclic tendency following a simple harmonic variation pattern, as this possibility was rejected on applying Edwards' method.

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