

Epidemiological analysis of mortality rates by causes in the Bay of Algeciras (2001-2005)

Concepcion Cruz Rojo, Manuel Almisas

Department of Preventative Medicine and Public Health, Faculty of Medicine, University of Sevilla, Sevilla, Spain.

Objectives

To analyse general mortality and premature mortality by causes of the inhabitants of the Bay of Algeciras, an area that is particularly exposed to atmospheric pollution.

Methodology

A comparison was made of rates adjusted by age and rates of loss of life expectancy from 1 to 70 years, by sex and causes of death, of the area studied (from 2001 to 2005), with the rest of Andalusia from (2001 to 2005) and Spain overall (2003) by the rate ratio (relative risk) and its confidence interval of 95% (CI95%), and the differences between rates (attributable risk).

Results

A statistically significant excess of general and premature mortality was found among men and women of the Bay of Algeciras, an area near the Straits of Gibraltar which suffers from high levels of atmospheric pollution. The relative risk of premature mortality among men is of 1.16 (CI95%: 1.15 – 1.17) compared to Andalusia and to 1.30 (CI95%: 1.29 – 1.32) compared to Spain overall, and among women of 1.17 (CI95%: 1.15 – 1.19) and 1.24 (CI95%: 1.22 – 1.26) respectively. Prominent among the major groups of causes of death found in the study are a greater risk of death due to infectious and parasitic diseases, respiratory diseases and malignant tumours. By specific causes, cardiac ischaemia and ill defined tumours in both sexes. Among men excessive premature and general mortality was found in tumours of the trachea, bronchi, lungs and bladder and hepatic cirrhosis.

Conclusions

A greater risk of premature and general mortality has been observed among men and women in the Bay of Algeciras, an area with a high concentration of industries and atmospheric pollution. It is intended to follow up with specific research projects and to propose concrete plans of action aimed at promoting sustainable economic development.

Key words: Mortality. Premature mortality. Causes of death. Atmospheric pollution.

Introduction

Mortality studies by geographic and social areas to detect zones of greater or lesser risk are common in Spain and other neighbouring countries. Their objectives are to highlight these risks and find possible explanations for their determining factors, including socio-economic ones. In Spain , many of these studies into general mortality rates, or causes such as cancer, have pointed to the provinces of Cadiz, Sevilla and Huelva as areas of greater risk, and studies into smaller areas within these provinces have highlighted the city of Cadiz and its Bay, the city of Sevilla and its environs, the Huelva delta, and the area comprising Algeciras and La Linea de la Concepcion^{1,2,3,4,5} .

The Bay of Algeciras includes a number of municipalities with a high concentration of industries, especially petrochemical and electrical, which pose a big risk of atmospheric pollution. To this must be added dense road and maritime traffic, around the port of Algeciras and its numerous businesses, which contribute to the serious environmental problem it suffers. The greater knowledge which exists, both within the scientific community and the general public, about the effects on health of the aforesaid pollution, has contributed to bring about a feeling of insecurity among the communities which are most affected and most aware of the situation, and of the necessity to come to a better understanding of their situation by more specific research, such as that carried by the Centro Superior de Investigaciones científicas (General Council for Scientific Research) and others, not published, carried out by the Departments for Health and the Environment of the Junta de Andalucía and the Andalusian School of Public Health^{6,7,8,9} .

The aim of this study is to analyse the general and premature mortality rate by major, and some specific, groups of causes, in the Bay of Algeciras, and to compare it to Andalucía and the rest of Spain. We wanted to ascertain that in this geographic location we would find a higher mortality rate, above all by causes of death related to areas exposed to higher levels of atmospheric pollution.

Subject matter and methodology

Area of study

The study was carried out in the locality of the Campo de Gibraltar, which comprises the municipalities of Algeciras, Los Barrios, San Roque and La Linea, which surround the Bay of Algeciras. The data on the general population and on different economic sectors was obtained from the population and housing census of the year 2001¹⁰, and data on the main industries and activity sectors from the directory of industrial sites produced by the Chamber of Commerce of the Campo de Gibraltar¹¹. The data on atmospheric emission and immission was taken from the records of threshold levels being exceeded in the province of Cadiz in the report EPER-Andalucia of the year 2005¹² and from the final report of the CSIC on the analysis of the environmental situation of the campo de Gibraltar area of December 2006⁹. The emission data was compared with data from the provinces of Cadiz, Sevilla and Huelva using the results contained in the Inventory of atmospheric emissions of Andalucia corresponding to the year 2005¹³, and the immission data was compared to data from some population centres in other areas of Spain referred to in the aforementioned CSIC report⁹.

Mortality indicators

The negative state of health of the population was analysed using a range of mortality indicators that were compared with the overall Andalusian and Spanish population, used as control groups.

The indicators used were rates adjusted by age per 100,000 inhabitants, by sex and cause of death. The direct method of standardisation was chosen using the standard European population. The causes chosen were the most frequent major groups of causes (or chapters), and in some, especially in the case of malignant tumours, more specific diseases (label G97) of the CIE-10¹⁴ were chosen. To measure premature mortality, rates adjusted per 100,000 inhabitants of life expectancy years lost (LEYL) from 1 to 70 years of age were calculated¹⁵.

Data on deaths of residents in the municipalities of the Bay of Algeciras and Andalucia during the years 2001 to 2005 was obtained from the Information and Publication Service of the Institute of Statistics of Andalucia. The population chosen was taken from the population and housing census of 2001, which despite not being in the middle of the period studied, we considered to be more

accurate and faithful to the reality of the inhabitants of the area¹⁰. Using this data the annual average mortality rates were calculated, thereby achieving greater reliability. With respect to the indicators used for Spain overall, and given that these are published annually by the Epidemiological Analysis and Health Status Section of the National Epidemiology Centre, for the purposes of comparison we chose the year representing the halfway point of the former period (2003), considering that since the area was so extensive it would ensure sufficient stability.

Statistical analysis

The mortality indicators of the Bay of Algeciras were compared to those of Andalucia and Spain by means of the rate ratio or relative risk (RR), calculating a confidence interval of approximately 95% (CI95%) with the Miettinen postulation¹⁶. The differences in the adjusted rates, or attributable risks (AR), were also evaluated by approximating the Poisson distribution to normal.

Results

The population of Algeciras, San Roque, Los Barrios and La Linea, of 202,078 inhabitants resides in a maximum radius of 7 km from the industrial complexes located in the centre of the Bay of Algeciras area (figure 1). The active population is 65,628 inhabitants of whom 10,046, that is 15.3% of the population¹⁰, work in manufacturing and in the production of electricity, water and gas. The study area is characterised by a high industrial concentration, especially the complexes in Palmones, Guadarranque and Puente Mayorga home to the major companies: conventional and combined cycle generating stations, petrochemical, steel and paper industries (annex 1). Table 1 sets out the levels of emission and immission of the major contaminants in the Bay of Algeciras, comparing them with other areas of Andalucia and Spain. It highlights that the emission of PM₁₀, SO₂ y NO_x of industrial origin are much higher than the emissions in the provinces of Huelva and Sevilla. Immission values of the four municipalities of the area of the Bay of Algeciras have higher concentrations of SO₄²⁻ and of NO₃⁻ (µg/m³) than the urban area of Alcobendas, but not as much when compared to industrial urban areas like Huelva and Tarragona. Also of note (especially in the industrial estate of Puente Mayorga) are higher values in the case of most metals, with the exception of titanium (TI).



Figure 1. Map of the Bay of Algeciras and location of its main industries.
Amended from the CSIC report: Analysis of the environmental situation of the vicinity of the
Campo de Gibraltar⁹. CTLB: Power plant Los Barrios. CELUPAL: currently Torrespapel.
Table 1. Comparison of the emissions and immissions of the major contaminants in the Bay of
Algeciras with other areas.

	Immissions ^d						
	Algeciras (2003/04)	Los Barrios (2005/06)	Puente Mayorga (San Roque) (2005)	La Línea (2005/06)	Alcobendas (2001)	Huelva (2003)	Tarragona (2001)
²⁻ ($\mu\text{g}/\text{m}^3$)	5,0	5,9	7,6	6,9	2,9	4,3	4,9
NO_3^- ($\mu\text{g}/\text{m}^3$)	3,5	3,2	3,6	4,4	2	2,8	3,9
Ti (ng/m^3)	31	29	30	27	30	54	21
V (ng/m^3)	25	20	37	26	4	5	6
Cr (ng/m^3)	6	15	23	16	2,6	0,6	2,5
Ni (ng/m^3)	11	13	29	16	2	6	4
Mn (ng/m^3)	8	15	22	16	10	9	9
Co (ng/m^3)	0,3	1	2,2	0,7	0,2	0,2	0,2

a. Source: Report on exceeding of threshold levels –EPER Andalucía 2005. Province of Cadiz. Data on firms that have exceeded pollution thresholds¹².

- b. Source: Inventory of atmospheric emissions in the autonomous region of Andalucía, 2005. Breakdown of data by province on all sectors of industrial activity¹³.
- c. In brackets, percentages for the province of Cadiz.
- d. Data from the final report in 2006 of the Analysis of the environmental situation of the area of the Campo de Gibraltar, by CSIC⁹.

The men of the Bay of Algeciras are at increased risk of mortality in causes as a whole compared to men in Andalucía (RR=1.15, CI95%:1.11-1.19, AR=134.30), and even more in respect to the rest of Spain (RR=1.33, CI95%: 1.28-1.38, AR 258.86). The same can be observed in the majority of the main chapters, showing higher relative risk in the group encompassing infectious and parasitic diseases (RR=2.05, CI95%: 1.67-2.51 in Andalucía; RR= 2.43, CI95%: 1.95-3.02 in Spain), and because of its higher attributable risk in the case of malignant tumours, and diseases of the respiratory and circulatory systems (table 2).

Table 2. General mortality rate by causes in men. Adjusted rates, relative risk and adjusted rate differences in the Bay of Algeciras (2001-2005), Andalucía (2001-2005) and Spain (2003).

Causes of death (CIE-10)	Bay of Algeciras ^a	Andalucía	RR	(CI95%)	Rate differences	Spain ^a	RR	(CI95%)	Rate differences
All chapters	1.043,32	909,02	1,15	(1,11-1,19)	134,30 ^c	784,46	1,33	(1,28-1,38)	258,86 ^c
I. Infectious and parasitic diseases	40,04	19,52	2,05	(1,67-2,51)	20,52 ^c	16,47	2,43	(1,95-3,02)	23,57 ^c
II. Tumours	307,40	267,64	1,15	(1,08-1,22)	39,76 ^c	250,21	1,23	(1,16-1,30)	57,19 ^c
Cancer of the larynx (C32) ^b	11,10	8,87	1,25	(0,96-1,62)	2,23	6,94	1,60	(1,19-2,13)	4,16 ^c
Cancer of the trachea, bronchi and lungs (C33-C34)	97,03	76,42	1,27	(1,16-1,39)	20,61 ^c	67,80	1,43	(1,30-1,57)	29,23 ^c
Stomach cancer (C16)	15,78	13,63	1,16	(0,94-1,43)	2,15	14,10	1,12	(0,91-1,38)	1,68
Cancer of the pancreas (C25)	11,09	8,38	1,32	(1,00-1,74)	2,71 ^d	9,82	1,13	(0,88-1,46)	1,27
Colon cancer (C18)	22,78	21,74	1,05	(0,88-1,24)	1,04	20,47	1,11	(0,93-1,33)	2,31
Cancer of the bladder (C67)	21,30	16,25	1,31	(1,08-1,59)	5,05 ^d	13,67	1,56	(1,27-1,92)	7,63 ^c
Cancer of the brain(C71)	4,95	5,40	0,92	(0,65-1,30)	-0,45	5,98	0,83	(0,59-1,14)	-1,03

Prostate cancer (C61)	22,60	20,75	1,09	(0,90–1,31)	1,85	20,65	1,09	(0,91–1,32)	1,95
Leukaemias(C91-C95)	8,79	7,39	1,19	(0,89–1,59)	1,40	6,71	1,31	(0,97–1,77)	2,08
Ill defined (C76-C80, C97)	25,10	16,41	1,53	(1,26–1,87)	8,69 ^c	17,08	1,47	(1,21–1,79)	8,02 ^c
IV. Glandular, endocrine diseases etc.	22,60	21,96	1,03	(0,83–1,27)	0,64	18,38	1,23	(0,98–1,55)	4,22
Diabetes (E10-E14)	20,24	18,91	1,07	(0,88–1,30)	1,33	15,12	1,34	(1,08–1,65)	5,12 ^c
V. Mental disorders	14,56	13,87	1,05	(0,80–1,39)	0,69	16,59	0,88	(0,68–1,13)	–2,03
VI-VII-VIII. Ear,eye, nervous systems	25,39	21,81	1,16	(0,95–1,43)	3,58	22,02	1,15	(0,94–1,42)	3,37
IX. Diseases of the circulatory system	315,58	289,29	1,09	(1,03–1,13)	26,29 ^d	223,65	1,41	(1,32–1,51)	91,93 ^c
Cardiac ischaemia (I20-I25)	109,00	75,54	1,44	(1,32–1,58)	33,46 ^c	87,89	1,24	(1,14–1,35)	21,11 ^c
Cerebrovascular (I60-I69)	76,41	83,66	0,91	(0,83–1,00)	–7,25	57,21	1,34	(1,20–1,49)	19,20 ^c
X. Respiratory diseases	145,18	110,89	1,31	(1,19–1,44)	34,29 ^c	95,18	1,53	(1,38–1,69)	50,00 ^c
XI. Digestive system diseases	54,49	55,13	0,99	(0,87–1,13)	–0,64	43,00	1,27	(1,09–1,47)	11,49 ^c
Cirrhosis (K70, K73, K74, K76)	22,70	15,49	1,46	(1,20–1,79)	7,21 ^c	17,79	1,28	(1,06–1,54)	4,91 ^d
XIV. Genitourinary diseases	24,39	18,73	1,30	(1,03–1,64)	5,66 ^d	16,12	1,51	(1,18–1,94)	8,27 ^c
XVIII. Ill defined	25,42	18,76	1,35	(1,07–1,71)	6,66 ^d	18,91	1,34	(1,06–1,70)	6,51 ^d
XX. External causes	51,27	54,14	0,95	(0,84–1,07)	–2,87	49,75	1,03	(0,91–1,17)	1,52

CI: confidence interval; AR: attributable risk; RR relative risk or rate ratio of mortality adjusted by age.

- a. Rates adjusted by age according to standard European population per 100,000 inhabitants.
- b. In brackets, codes for specific causes corresponding to the G97 of the CIE-10 ^a.
- c. $p < 0.01$
- d. $p < 0.05$.

By the specific causes studied, we highlight the higher mortality rate among men in the Bay of Algeciras represented by tumours of the trachea, bronchi and lungs (RR=1.27, CI95%: 1.16-1.39; and RR=1.43, CI95%:1.30-1.57; RA=20.61 and RA=29.23, in Andalusia and Spain, respectively), cardiac ischaemia (RR=1.44, CI95%:1.32-1.58, and RR=1.24, CI95%:1.14-1.35; AR=33.46 and AR=21.11, respectively), as well as bladder tumours and ill defined tumours and hepatic cirrhosis. Higher mortality rates due to cancer of the pancreas in the area can only be observed in relation to Andalusia, and in the case of cancer of the larynx, diabetes mellitus and vascular cerebral diseases only in relation to the rest of Spain (table 2). The women in the area of the Bay of Algeciras, although with lower adjusted rates, also have a statistically significant higher mortality rate in causes as a whole compared with Andalusia (RR=1.13, CI95%: 1.09-1.17, AR=68.01), and greater still compared to the rest of Spain (RR=1.34, CI95%:1.29-1.39, AR=151.23) (table 3). Among the major groups causing a higher mortality rate among women are respiratory diseases (RR=1.62, CI95%: 1.44-1.81; RR=1.75, CI95%:1.55-1.96), followed by infectious and parasitic diseases, malignant tumours, genitourinary diseases and ill-defined causes (table 3). By specific causes, colon and ill-defined tumours and cardiac ischaemia predominate, the latter standing out because of the rate difference and with a relative risk of 1.38 (CI95%: 1.23-1.54) with regard to Andalusia and 1.23 (CI95%: 1.11-1.37) with regard to Spain. In the case of tumours of the trachea, bronchi and lungs, the mortality rate is significantly lower in the area with regard to the rest of Spain, and no significant differences have been found with respect to Andalusia (table 3).

Table 3. General mortality by causes in women. Adjusted rates, relative risk and adjusted rate difference in the Bay of Algeciras (2001-2005), Andalusia (2001-2005) and Spain (2003).

Causes of death (CIE-10)	Bay of Algeciras ^a	Andalucía	RR	(CI95%)	Rate differences	Spain ^a	RR	(CI95%)	Rate differences
All chapters	593,96	525,99	1,13	(1,09-1,17)	68,01 ^c	442,77	1,34	(1,29-1,39)	151,23 ^c
I. Infectious and parasitic Diseases	13,99	8,99	1,56	(1,19-2,04)	5,00 ^c	8,91	1,57	(1,20-2,06)	5,08 ^c

II. Tumours	132,19	116,85	1,13	(1,05–1,22)	15,34 ^c	111,73	1,18	(1,09–1,28)	20,46 ^c
Cancer of the larynx (C32) ^b	0,37	0,25	1,49	(0,34–6,54)	0,12	0,30	1,23	(0,31–4,83)	0,07
Cancer of the trachea, bronchi and lungs (C33-C34)	5,74	6,44	0,89	(0,67–1,18)	–0,70	7,58	0,76	(0,59–0,98)	–1,84 ^d
Stomach cancer (C16)	6,62	5,61	1,18	(0,89–1,57)	1,01	6,47	1,02	(0,79–1,33)	0,15
Cancer of the pancreas (C25)	6,50	4,98	1,31	(0,95–1,80)	1,52	5,78	1,12	(0,84–1,51)	0,72
Colon cancer (C18)	16,17	12,39	1,31	(1,08–1,59)	3,78 ^d	11,46	1,41	(1,16–1,72)	4,71 ^c
Cancer of the bladder (C67)	2,30	1,90	1,22	(0,77–1,95)	0,40	1,76	1,31	(0,82–2,13)	0,54
Cancer of the brain (C71)	3,87	3,77	1,03	(0,70–1,55)	0,10	3,67	1,05	(0,72–1,57)	0,20
Breast cancer (C50)	21,67	21,39	1,01	(0,87–1,18)	0,28	19,92	1,09	(0,93–1,28)	1,75
Leukaemias (C91-C95)	4,99	4,29	1,16	(0,83–1,62)	0,70	4,07	1,23	(0,87–1,72)	0,92
Ill defined (C76-C80, C97)	12,20	8,44	1,44	(1,14–1,82)	3,76 ^c	8,62	1,42	(1,12–1,77)	3,58 ^c
IV. Glandular, endocrine diseases, etc.	22,28	22,51	0,99	(0,84–1,17)	–0,23	16,66	1,34	(1,11–1,65)	5,62 ^c
Diabetes (E10-E14)	19,20	18,54	1,03	(0,89–1,20)	0,66	13,36	1,44	(1,21–1,71)	5,84 ^c
V. Mental illness	19,22	13,51	1,42	(1,16–1,74)	5,71 ^c	17,28	1,11	(0,93–1,33)	1,94
VI-VII-VIII. Ear, eye, nervous systems	21,80	19,60	1,11	(0,94–1,32)	2,20	20,78	1,05	(0,89–1,24)	1,02
IX. Diseases of the circulatory system	214,64	212,48	1,01	(0,96–1,06)	2,16	152,20	1,41	(1,33–1,50)	62,44 ^c
Cardiac ischaemia (I20-I25)	47,50	34,51	1,38	(1,23–1,54)	12,99 ^c	38,53	1,23	(1,11–1,37)	8,97 ^c
Cerebrovascular (I60-I69)	57,30	70,87	0,81	(0,75–0,87)	–13,57 ^c	46,62	1,23	(1,12–1,35)	10,68 ^c
X. Diseases of the respiratory system	68,04	42,04	1,62	(1,44–1,81)	26,00 ^c	38,98	1,75	(1,55–1,96)	29,06 ^c

XI. Diseases of the digestive system	29,03	26,88	1,08	(0,93-1,25)	2,15	21,49	1,35	(1,14-1,59)	7,54 ^c
Cirrhosis (K70, K73, K74, K76)	5,20	4,48	1,17	(0,84-1,61)	0,72	5,50	0,95	(0,71-1,28)	-0,30
XIV. Genitourinary diseases	19,44	13,40	1,45	(1,18-1,78)	6,04 ^c	10,40	1,87	(1,48-2,35)	9,04 ^c
XVIII. Ill defined	21,45	17,07	1,25	(1,05-1,50)	4,38 ^d	13,90	1,54	(1,26-1,88)	7,55 ^c
XX. External causes	12,94	15,38	0,84	(0,68-1,04)	-2,44	15,86	0,82	(0,66-1,01)	-2,92

CI: confidence interval; AR: attributable risk; RR: relative risk or rate ratio of mortality adjusted by age.

- Rates adjusted by age according to the standard European population per 100,000.
- In brackets, codes for specific causes corresponding to G97 of the CIE-10^a.
- p<0.01.
- p<0.05

When we analyse premature mortality we again find higher, statistically significant, adjusted rates of years of life expectancy lost, among men in the Bay of Algeciras in causes of death as a whole and in most of the major groups of causes, as well as mental disorders and diseases of the eye, ear and nervous systems. Particularly noteworthy are infectious and parasitic diseases, with relative risks of 2.55 (CI95%:2.45-2.66) and 3.69 (CI95%: 3.51-3.87) and rate differences of 5564.72 and 676.54 in Andalucia and Spain, respectively, as well as diseases of the eye, ear and nervous systems, diseases of the circulatory system and malignant tumours (table 4). It was found that, unlike the case with general mortality, there were no significant differences in premature mortality rates due to respiratory diseases in relation to Spain as a whole. As for specific causes, hepatic cirrhosis and cardiac ischaemia are seen to represent the greatest risk of premature death in the area in respect to Andalucia and to Spain, and in the site of tumours, again tumours of the trachea, bronchi, lungs, bladder and ill-defined prevail once more, but now, in addition, a higher premature mortality rate was found due cancer of the pancreas, of the colon, leukaemias and cancer of the larynx (which before did not show a higher death rate with respect to Andalucia). (table 4).

Table 4. Premature mortality by causes in men. Rates adjusted by potential life expectancy years lost (PLEYL), relative risk and adjusted rate differences of PLEYL in the Bay of Algeciras (2001-2005), Andalucia (2001-2005) and Spain (2003).

Causes of death (CIE-10)	Bay of Algeciras ^a	Andalucía	RR	(CI95%)	Rate differences	Spain ^a	RR	(CI95%)	Rate differences
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All chapters	6.432,16	5544,67	1,16	(1,15–1,17)	887,49 ^c	4.934,91	1,30	(1,29–1,32)	1.497,25 ^c
I. Infectious and parasitic diseases	928,26	363,54	2,55	(2,45–2,66)	564,72 ^c	251,72	3,69	(3,51–3,87)	676,54 ^c
II. Tumours	1.759,03	1655,94	1,06	(1,04–1,09)	103,09 ^c	1.548,08	1,14	(1,11–1,16)	210,95 ^c
Cancer of the larynx (C32) ^b	77,96	65,26	1,19	(1,09–1,31)	12,70 ^c	55,03	1,42	(1,28–1,57)	22,93 ^c
Cancer of the trachea, bronchi and lungs (C33–C34)	552,15	465,00	1,19	(1,15–1,23)	87,15 ^c	444,52	1,24	(1,20–1,29)	107,63 ^c
Stomach cancer (C16)	55,92	87,09	0,64	(0,59–0,70)	–31,17 ^c	78,93	0,71	(0,65–0,77)	–23,01 ^c
Cancer of the pancreas (C25)	88,16	61,05	1,44	(1,31–1,59)	27,11 ^c	66,34	1,33	(1,21–1,45)	21,82 ^c
Colon cancer (C18)	126,31	95,48	1,32	(1,23–1,44)	30,83 ^c	87,21	1,45	(1,34–1,57)	39,10 ^c
Cancer of the bladder (C67)	61,38	48,47	1,27	(1,14–1,41)	12,91 ^c	44,38	1,38	(1,24–1,55)	17,00 ^c
Cancer of the brain (C71)	85,67	77,26	1,11	(1,02–1,20)	8,41 ^d	81,83	1,05	(0,97–1,13)	3,84
Prostate cancer (C61)	19,12	24,27	0,79	(0,67–0,92)	–5,15 ^c	22,48	0,85	(0,73–1,00)	–3,36
Leukaemias (C91–C95)	107,48	81,11	1,33	(1,23–1,43)	26,37 ^c	70,53	1,52	(1,40–1,66)	36,95 ^c
III defined (C76–C80, C97)	137,94	109,09	1,26	(1,18–1,36)	28,85 ^c	98,80	1,40	(1,30–1,50)	39,14 ^c
IV. Glandular and endocrine diseases, etc.	82,77	87,96	0,94	(0,83–1,03)	–5,19	69,57	1,19	(1,07–1,329)	13,20 ^c
Diabetes (E10–E14)	54,22	53,45	1,01	(0,92–1,12)	0,77	38,44	1,41	(1,25–1,59)	15,78 ^c
V. Mental disorders	81,43	58,14	1,40	(1,25–1,56)	23,29 ^c	49,80	1,64	(1,45–1,84)	31,63 ^c
VI–VII–VIII Ear, eye, nervous systems	250,13	157,54	1,59	(1,49–1,69)	92,59 ^c	131,69	1,90	(1,77–2,04)	118,74 ^c
IX. Diseases of the circulatory system	1.107,94	1003,4	1,10	(1,07–1,14)	104,54 ^c	797,16	1,39	(1,35–1,43)	310,78 ^c
Cardiac ischaemia (I20–I25)	436,72	371,38	1,18	(1,13–1,22)	65,34 ^c	396,36	1,10	(1,06–1,14)	40,36 ^c

Cerebrovascular (I60-I69)	221,31	194,91	1,14	(1,08–1,20)	26,40 ^c	144,01	1,54	(1,44–1,63)	77,30 ^c
X. Diseases of the respiratory system	233,33	209,82	1,11	(1,05–1,18)	23,51 ^c	220,93	1,06	(1,00–1,12)	12,40
XI. Diseases of the digestive system	397,92	379,63	1,05	(1,00–1,10)	18,29 ^d	308,13	1,29	(1,23–1,36)	89,79 ^c
Cirrhosis (K70, K73, K74, K76)	271,24	150,57	1,80	(1,70–1,91)	120,67 ^c	195,31	1,39	(1,32–1,46)	75,93 ^c
XIV. Genitourinary diseases	52,86	38,52	1,37	(1,20–1,57)	14,34 ^c	31,18	1,70	(1,46–1,97)	21,68 ^c
XVIII. Ill defined	45,62	37,91	1,20	(1,05–1,38)	7,71 ^d	158,56	0,29	(0,27–0,31)	–112,94 ^c
XX. External causes	1.352,60	1425,41	0,95	(0,93–0,97)	–72,81 ^c	1.280,97	1,06	(1,03–1,08)	71,63 ^c

PLEYL: Potential life expectancy years lost from 1 to 70; CI: confidence interval. AR; attributable risk; RR: relative risk, or rate ratio of mortality adjusted by age.

- a. Rates of PLEYL adjusted by age according to the standard European population per 100,000 inhabitants.
- b. In brackets, codes for specific causes corresponding to the G97 of the CIE-10^a.
- c. $p < 0.01$.
- d. $p < 0.05$.

There is also a higher premature mortality death rate among women in the Bay of Algeciras, with statistically significant differences with respect to Andalucía and to Spain, in causes as a whole and in the most important chapters, but with the addition of diseases of the ear, eye and nervous systems. Particularly noteworthy are infectious and parasitic diseases, with relative risks of 1.95 (CI95%: 1.79-2.11) and 1.92 (CI95%: 1.77-2.08), and attributable risks of 90.96 and 89.64; diseases of the circulatory system (RR=1.36, CI95%: 1.29-1.42; RR=1.70; CI95%: 1.61-1.79; AR =116.62 and AR =182.16); malignant tumours and respiratory diseases (table 5). In the site of tumours, the figures are higher for cancers of the pancreas, brain and ill defined, while premature mortality due to tumours of the trachea, bronchi and lungs is lower than that of Andalucía but higher than the rest of Spain (table 5).

Table 5. Premature mortality by causes among women. Rates adjusted by potential life expectancy years lost PLEYL, relative risk and differences of adjusted rates of PLEYL in the Bay of Algeciras (2001-2005), Andalucía (2001-2005) and Spain (2003).

Causes of death (CIE-10)	Bay of Algeciras ^a	Andalucía	RR	(CI95%)	Rate differences	Spain ^a	RR	(CI95%)	Rate differences (AR)
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All chapters	2585,69	2208,75	1,17	(1,15–1,19)	376,94 ^c	2085,23	1,24	(1,22–1,26)	500,46 ^c
I. Infectious and parasitic diseases	187,20	96,24	1,95	(1,79–2,11)	90,96 ^c	97,56	1,92	(1,77–2,08)	89,64 ^c
II. Tumours	1097,57	983,89	1,12	(1,09–1,15)	113,68 ^c	897,99	1,22	(1,19–1,26)	199,58 ^c
Cancer of the larynx (C32) ^b	2,67	2,33	1,15	(0,70–1,87)	0,34	3,29	0,81	(0,53–1,23)	–0,62
Cancer of the trachea, bronchi and lungs (C33–C34)	44,09	63,59	0,69	(0,63–0,76)	–19,50 ^c	28,66	1,54	(1,34–1,76)	15,43 ^c
Stomach cancer (C16)	41,74	40,04	1,04	(0,93–1,17)	1,70	40,58	1,03	(0,92–1,15)	1,16
Cancer of the pancreas (C25)	58,62	27,44	2,14	(1,86–2,45)	31,18 ^c	28,66	2,05	(1,79–2,34)	29,96 ^c
Colon cancer (C18)	69,16	66,43	1,04	(0,95–1,14)	2,73	61,87	1,12	(1,02–1,23)	7,29 ^d
Cancer of the bladder (C67)	2,67	5,42	0,49	(0,36–0,68)	–2,75 ^c	6,22	0,43	(0,32–0,58)	–3,55 ^c
Cancer of the brain (C71)	75,40	54,79	1,38	(1,25–1,51)	20,61 ^c	49,85	1,51	(1,37–1,67)	25,55 ^c
Breast cancer (C50)	223,91	242,34	0,92	(0,88–0,97)	–18,43 ^c	207,52	1,08	(1,03–1,13)	16,39 ^c
Leukaemias (C91–C95)	59,02	59,63	0,99	(0,90–1,09)	–0,61	50,36	1,17	(1,06–1,30)	8,66 ^c
Ill defined (C76–C80, C97)	89,25	48,65	1,83	(1,66–2,03)	40,60 ^c	54,55	1,64	(1,49–1,80)	34,70 ^c
IV. Glandular and endocrine diseases, etc.	56,17	60,94	0,92	(0,83–1,03)	–4,77	44,31	1,27	(1,12–1,44)	11,86 ^c
Diabetes (E10–E14)	30,57	25,41	1,20	(1,04–1,39)	5,16 ^d	17,17	1,78	(1,50–2,12)	13,40 ^c
V. Mental disorders	18,99	15,98	1,19	(0,97–1,45)	3,01	14,87	1,28	(1,04–1,57)	4,12 ^d
VI–VII–VIII. Ear, eye, nervous	113,31	92,29	1,23	(1,12–1,34)	21,02 ^c	102,12	1,11	(1,02–1,21)	11,19 ^d
IX. Diseases of the circulatory system	442,70	326,08	1,36	(1,29–1,42)	116,62 ^c	260,54	1,70	(1,61–1,79)	182,16 ^c
Cardiac ischaemia (I20–I25)	121,79	72,06	1,69	(1,55–1,84)	49,73 ^c	68,02	1,79	(1,64–1,96)	53,77 ^c
Cerebrovascular (I60–I69)	99,72	101,12	0,99	(0,92–1,06)	–1,40	83,17	1,20	(1,11–1,30)	16,55 ^c
X. Diseases of the respiratory system	127,07	71,30	1,78	(1,61–1,97)	55,77 ^c	81,56	1,56	(1,42–1,71)	45,51 ^c

XI. Diseases of the digestive system	84,68	100,49	0,84	(0,77–0,92)	–15,81 ^c	94,42	0,90	(0,82–0,98)	–9,74 ^d
Cirrhosis (K70, K73, K74, K76)	31,57	29,53	1,07	(0,94–1,22)	2,04	49,10	0,64	(0,58–0,71)	–17,53 ^c
XIV. Genitourinary diseases	31,57	27,55	1,15	(0,97–1,35)	4,02	10,38	3,04	(2,36–3,98)	21,19 ^c
XVIII. Ill defined	14,47	10,68	1,35	(1,04–1,76)	3,79 ^d	52,43	0,28	(0,27–0,31)	–37,96 ^c
XX. External causes	296,72	319,42	0,93	(0,89–0,97)	–22,70 ^c	338,96	0,88	(0,84–0,92)	–42,24 ^c

PLEYL: Potential life expectancy years lost from 1 to 70; CI: confidence interval. AR; attributable risk; RR: relative risk or rate ratio of mortality adjusted by age.

- a. Rates of PLEYL adjusted by age according to the standard European population per 100,000 inhabitants.
- b. In brackets, codes for specific causes corresponding to the G97 of the CIE-10^a.
- c. $p < 0.01$.
- d. $p < 0.05$.

Discussion

We have analysed mortality rates over five recent years in the population of the Bay of Algeciras, an area that has a high level of atmospheric pollution due to a high concentration of industries. In this geographical framework, the population of the Bay of Algeciras suffers from a clear excessive general and premature mortality rate compared to Andalucia, and to an even greater extent, when compared to Spain as a whole. Causes of death, in both sexes, which the study highlights are parasitic and infectious diseases, respiratory diseases and malignant tumours. Excess mortality due to diseases of the circulatory system, is linked to excessive risk of cardiac ischaemia. This same situation is reflected in the case of premature mortality, to which can be added diseases of the ear, eye and nervous systems, though respiratory diseases in men only present an increased risk of premature death when compared to Andalucia. Although no significant differences in general and premature mortality have been found in diseases of the digestive system, an excessive risk of death due to hepatic cirrhosis was observed among men.

As regards the greater risk of mortality due to infectious and parasitic diseases, and although this group includes a wide variety of transmissible diseases, among them is the one that which is producing the highest mortality due to infection in recent decades in our country: infection by the human immunodeficiency virus and AIDS. Therefore it is very probable that this excess mortality is due to the aforesaid infection, whose incidence and mortality rate are very high in this area, related to drug trafficking and consumption, which is determined, among other social circumstances, by its geographical location¹⁷. This

situation could also be contributing to the excessive death rate due to hepatic cirrhosis in men.

Respiratory and cardiovascular diseases encompass a variety of conditions with multiple causes and individual determining factors, like dietary habits, occupational exposure and smoking ^{18,19}. Furthermore, numerous studies have shown the short and long term effects of atmospheric pollution on respiratory, lung and circulatory function, producing a higher incidence of, and mortality due to respiratory ^{20,12, 22, 23, 24} and cardiovascular ^{20, 21,22, 23, 25} diseases, even though other risk factors such as tobacco were controlled in the studies.

The site of tumours that have produced an excessive general and premature mortality rate among men in the area in respect to Andalusia and Spain are tumours of the trachea, bronchi and lungs, tumours in the bladder, ill defined ones, cancer of the pancreas and of the larynx, and only in the case of excessive premature death rate, cancer of the colon and leukaemias. Among women, excessive general mortality is observed due to cancer of the colon and ill defined tumours and in premature death rate, once again ill defined tumours and tumours of the brain and pancreas. Among the factors involved in the origin of tumours of the trachea, bronchi and lungs are smoking and the exposure, especially occupational exposure, to substances such as radon, asbestos, polycyclic aromatic hydrocarbons, arsenic, chromium and nickel, as well as atmospheric pollution, though in many of the studies in which this connection has been established factors which could interfere with the findings, such as tobacco addiction, have been controlled ^{5,21,22,26,27,28,29}. Factors associated with cancer of the bladder are, as well as smoking, exposure to substances present in the work place, in water, in the soil such as aromatic amines and arsenic. The effects that atmospheric pollution has upon this tumour and others such as the haematopoietic system and the larynx have also been studied ^{5,26,30,31,32,33}.

Factors associated with causing leukaemias are ionizing radiation and benzene; smoking and the consumption of alcohol, as well as occupational exposure to wood, carbon and petroleum-derived particles have been linked to tumours of the larynx. There is less evidence on the causes of cancer of the pancreas, although it has been associated, among others, with contaminants such as nickel, pesticides and polycyclic aromatic hydrocarbons. In relation to cancer of the colon, it has to be noted that mortality rates do not reflect its true incidence due to higher survival rates recently in our country, its principal known risk factors being dietary habits, linked to an excessive consumption of meat and animal fats, and a diet low in fibre and antioxidants ^{5,30}.

Despite the importance that tobacco has in the origin of many of the diseases that are responsible for an excessive mortality rate in the area studied, and even though we do not have a breakdown, at this level, of tobacco addiction rates, it has nevertheless been established that neither Andalusia nor the province of Cadiz show appreciable differences in respect to Spain as a whole on the prevalence of smoking, and that moreover successive health surveys from 1987, show a tendency towards equalization of tobacco addiction rates ³⁴.

Geographical studies and studies on the effect of social inequalities on health consistently show that areas with worse social and economic indicators have a higher mortality rate, due to the principal causes of death, like cardiovascular diseases and malignant tumours^{4,5,35}. We are aware that the area studied, like Andalusia as a whole, has unfavourable socioeconomic indicators, so that the excessive mortality rate could be put down to uneven economic and industrial development in the area^{5,35}.

Some of the limitations of this study arise from the unreliability of some rates due to random causes in a relatively small area. That was one of the drawbacks in choosing the direct, versus the indirect, method of standardising, and despite this we chose the first and opted to calculate the average annual rates over a period of five years, which has allowed us to make direct comparisons with control areas. Also, due to the low death rate amongst the younger population, it was not possible to analyse juvenile and infant mortality, which is where excessive premature mortality found in causes like diseases of the nervous system (more specifically identified, not grouped with eye and ear diseases) and leukaemias could be occurring. Despite these limitations, we think we achieved our main objective which was to establish the higher risk of mortality from major causes of death among men and women in the municipalities surrounding the Bay of Algeciras.

These results point to the importance of continuing research in order to better understand the risk posed in the area studied and its determining factors. We think that it is also necessary to put forward specific action plans to deal with one of the possible sources of the problem, as the people of the area have been claiming for some time, all the more so when current public administrative planning for the area envisages, not the limitation of industrial concentration and communication networks, but rather accelerating and enhancing economic development to increasingly unsustainable levels.

Main industries in the area of the Bay of Algeciras

Town	Name	Activity
Algeciras	Torraspapel	Paper manufacture
	APM Terminals	Container terminal in the port of Algeciras
Los Barrios	Acerinox	Stainless steel manufacture
	Los Barrios generating station	Electric power generation
San Roque	Interquisa	Manufacture of purified terephthalic acid (PTA) and purified terephthalic acid (PIPA), main raw materials for the polyester industry
	Artenius San Roque	Manufacture of PET (poly-ethylene terephthalate)
	Combined cycle generating plant	Electric power and steam generation
	Campo de Gibraltar (NGS)	

	Bahía de Algeciras (Enel-Viesgo) generating station	Generation of electric power
	Combined cycle generating plant (Endesa Generación)	Generation of electric power
	Gas natural SDG	Generation of electric power
	Grupo CEPSA-Refinería	Petrochemical factory and manufacture of lubricants
	Gibraltar (Petresa y Lubrisur)	
	Factoría GLP-Repsol YPF	Storage, packaging and transport of liquefied petroleum gases
	Abelló Linde	Production, distribution and sale of gaseous products
	Oxígeno Andalucía (Air Liquide)	Manufacture of industrial and medical gaseous products

Source: Chamber of Commerce Campo de Gibraltar. Directory of industrial sites¹¹.

Correspondence: cruzrojo@us.es

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