Years of Life Lost due to Acute Myocardial Infarction in Argentina between 1991 and 2005

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ABSTRACT

Background
Years of potential life lost (YPLL) is an indicator used to illustrate premature mortality. In opposition to crude mortality rates adjusted by years, YPLL represents the number of years theoretically not lived by an individual who dies prematurely (before the predicted life expectancy). By emphasizing the loss of life at an early age, YPLL focuses attention on the need to deal with the major causes of early deaths, and the use of this indicator is justified in planning and defining health priorities.

Objectives
To describe the evolution of mortality due to acute myocardial infarction (AMI) in terms of mortality rate (MR) and years of potential life lost (YPLL) between 1991-2005, identify sex-related differences and compare mean YPLL per decease between the registries of the SAC and of the Office of Statistics and Health Information, Ministry of Health and Social Services (DEIS).

Material and Methods
Data from deaths due to AMI distributed by age and sex were retrieved from the DEIS and SAC registries. YPLL were estimated by Romeder and Mc Whinnie's method and were also based on life expectancy at birth as well as mean YPLL with its corresponding 95% confidence interval.

Results
Mortality rate for AMI decreased from 50/100,000 inhabitants in 1991 to 38/100,000 in 2005 (slope -3.7; $p<0.001$). YPLL decreased from 516 to 314 years/100,000 during the same period. National YPLL were 11.3 (11.1-11.5), 11.4 (11.2-11.6), 11.5 (11.3-11.7), 11.1 (10.8-11.3) for 1991, 1996, 2000 and 2005, respectively (slope 0.0). These results were similar to those of the SAC registries: 10.8 (8.22-13.5), 10.4 (6.86-14.0), 7.50 (4.67-10.3), 14.0 (10.3-17.7) for the same years (slope +0.67). No significant differences were reported among both sexes, except for women in 2000 ($p<0.05$).

Conclusions
The use of mean YPLL demonstrated an absence of reduction in premature death due to AMI in Argentina. This result is not perceptible in the analysis of mortality rate which showed a decline during the study period.

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Key words > Myocardial Infarction - Years of Potential Life Lost - Epidemiology

Abbreviations >

YPLL	Years of potential life lost	**AMI**	Acute myocardial infarction
DEIS	Office of Statistics and Health Information, Ministry of Health and Social Services (*Dirección de Estadística e Información de Salud del Ministerio de Salud y Acción Social*)	**AYPLL**	Average years of potential life lost
		SAC	Argentine Society of Cardiology (*Sociedad Argentina de Cardiología*)
		MR	Mortality rates
LE	Life expectancy		

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BACKGROUND

Acute Myocardial infarction is one of the main causes of deaths in Argentina and carries high economic, health and human costs. (1-3)

Crude or age-adjusted mortality rates are one of the indicators of health status most frequently used and easy to estimate, that express the risk of death in a population; however, they are highly influenced by health problems of the more advanced age groups, where most deaths occur. (4, 5) Years of potential life lost (YPLL) is an indicator used to illustrate premature mortality and represents the number of years theoretically not lived by an individual who dies prematurely (before the predicted life expectancy). By emphasizing the loss of life at an early age, YPLL focuses attention on the need to deal with the major causes of premature deaths, and the use of this indicator is justified in planning and defining health priorities. (6, 7)

A death is considered premature when it occurs before a given predetermined age corresponding, for example, to life expectancy at birth in the population under study. Considering the age of death rather than the mere event of death allows assigning a different weight to deaths that occur at different moments of life. (5)

The aims of the present study was to describe the development of mortality due to acute myocardial infarction (AMI) in Argentina using YPLL between 1991-2005 and to identify gender-related differences between the registries of the SAC (8) and vital statistical reports of the DEIS. (9)

MATERIAL AND METHODS

Data from deaths due to AMI were obtained from the SAC registries corresponding to the years 1991, 1996, 2000 and 2005. (8) Age and gender from each dead patient were retrieved to estimate YPLL. Nationwide data from DEIS registries included age of death due to AMI as well as crude mortality rates and YPLL per 100,000 population. (9)

There are different methods to estimate YPPL; however, all of them use two parameters. Firstly, age interval (upper and lower age limits) considered for calculation should be indicated. These age limits differ according to the method used; if the lower limit is 0 years and the upper limit is life expectancy (LE) at birth, deaths above LE will not be included. Secondly, weighting factor is the other parameter used and it specifies the number of years each death contributes to total YPLL. In this case, the two weighting factors most frequently used are the difference between the age of death and a constant upper limit (generally about 65 to 70 years) or LE according to charts of the study population. The combination of both parameters generates a great varieties of methods to estimate YPLL. (10)

The use of life expectancy at birth as an age limit for the YPLL adjusts the calculation to the population profile of the country or area. This is very important to remember in order to avoid making comparisons between two or more territories with different life expectancies. Yet, there is lack of agreement between researchers regarding age limits for calculating YPLL. Based on these considerations, YPLL were estimated using Romeder and McWhinnie's method, (11):

$$YPLL = \Sigma\ Ai\ Di$$

were:

i = age interval considered.

Ai = difference in years between the class mark and the remaining years to live until age 70 when death occurs in that age interval.

Di = number of deaths due to AMI in each age interval i.

It is recommended to use class mark so that the assumption of a uniform distribution of deaths is more realistic. (5) Death data were grouped in 5-year age intervals, a method used by several authors and by the DEIS. In addition, YPLL for 1995-2005 were calculated according to LE in Argentina in order to perform a sensitivity analysis of this parameter.

National data were compared to SAC registries using average YPLL (12) (AYPLL) which results by dividing total YPPL by the total number of deaths, with its corresponding 95% confidence interval (95% CI).

Time-trend analyses of YPLL and of crude mortality rates due to AMI were performed using the linear regression slope of each time series. Proportions, mortality rates and APYLL were compared using chi square test, z -test and graphic representation of confidence intervals for a threshold value of 0.05, respectively. We did not use ANOVA to compare the slopes of the linear regression as we considered it was unnecessary.

Data from deaths due to AMI in Argentina were retrieved from DIES database corresponding to vital statistics records of the years 1991, 1996, 2000 and 2005. Based on the principles and guidelines of the Pan American Health Organization to strengthen vital statistics systems, we adopted the International Classification of Diseases, Ninth Revision (ICD-9), (13) and Tenth Revision (ICD-10). (14) The cause of death was identified by ICD-9 code 410 for the period 1991-1996 and by ICD-10 code I21 for the period 2000-2005, which cover acute myocardial infarction. The Appendix summarizes the formulas used in this study.

RESULTS

Crude mortality rate and YPLL rate due to AMI in Argentina per 100,000 population were analyzed between 1991 and 2005. (Figures 1 and 2) Mortality rate for AMI decreased from 50 per 100,000 population in 1991 to 38 per 100,000 population in 2005 ($p<0.001$); this difference implies a reduction of 24%. Figure 2 shows that YPLL per 100,000 population decreased from 516 to 314 in 2005, a reduction of 39% using Romeder and McWhinnie's formula, and from 612 to 458 when LE was considered. Sensitivity analysis demonstrated that when LE was used, YPLL reduction was lower compared to the figure obtained using Romeder and McWhinnie's formula (25% *versus* 39%, $p = 0.03$). The same fall was confirmed by the Pan American Health Organization; the 1988 reported showed that Argentina, together with Canada, Chile and the United States, is one of the American countries that has experienced a reduction in the rates of YPLL due to coronary artery disease. (2)

Differences in YPLL related to gender are shown in Figure 2, with a reduction of YPLL of 37% in men (from 812 to 510 per 100,000 men) and 47% in women during the same period (from 219 to 125 per 100,000 women) according to the formula of Romeder and McWhinnie. However, when YPLL was estimated based on LE, the reduction was 18% in men and 32% in women (sensitivity analysis, p = 0,0009 and p = 0,208, respectively). Years of potential life lost rates were significantly greater in men than in women. In fact, premature mortality in men is attributed to deaths due to AMI, and this finding is confirmed by the bibliography available that estimates that the latter is three to five times more frequent in men than in women. (2)

Table 1 describes the population analyzed, divided in periods of five years, and the number of deaths with data retrieved from the Office of Statistics and Health Information, Ministry of Health and Social Services and from the sub-analysis of the SAC registries used to estimate YPLL rates as well as AYPLL per decedent.

The analysis of the proportion of gender-related YPLL due to AMI for the years 1991, 1996, 2000 and 2005 indicates that 78%, 80%, 79% and 80%, respectively (DEIS data) and 80%, 69%, 83% and 83%, respectively (SAC registries) corresponded to men.

Figure 3 illustrates the distribution of YPLL per 100,000 population, separated between men and women during the period 1991-2005 according to the formula of Romeder and McWhinnie. It can be noted that premature mortality due to AMI is more frequent in male gender. In men, the peak in mortality occurred in the age group from 55 to 59 years, while in women it happened a 5-year period later.

Average YPLL was used to compare YPLL due to AMI between data from DEIS and SAC registries, as this measurement allows the assessment of the average years of potential life lost per decedent due to AMI. The graph in Figure 4 shows that, according to the formula of Romeder and McWhinnie, AYPLL nationwide were 11.3 (11.1-11.5), 11.4 (11.2-11.6), 11.5 (113-11.7) and 11.1 (10.8-11.3) for the period 1991, 1996, 2000 and 2005,respectively (slope 0.0). These results were similar to AYPLL analyzed in the SAC registries: 10.8 (8.22-13.5), 10.4 (6.86-14.0), 7.50 (4.67-10.3) and 14.0 (10.3-17.7), for the aforementioned years (slope +0.67), except for the year 2000, when 95% CI did not overlap (statistical significance for the value of 0.05 was determined by the graphic representation of confidence intervals). The same figure compares AYPLL based on LE which are greater than those obtained with an upper age limit greater than 70 years: DEIS 13.4 (13.1-13.5), 14.5 (14.2-14.6), 15.6 (15.3-15.7) and 16.2 (15.8-16.3), and SAC 12.9 (10.2-15.5), 13.5 (9.86-17.0), 11.6 (8.67-14.3) and 19.1 (15.3-22.7).

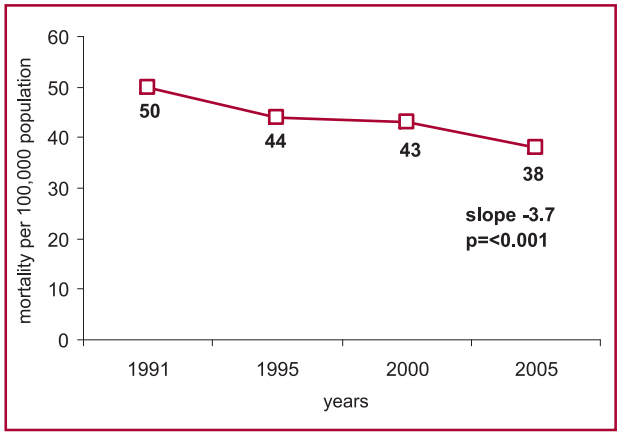

Fig. 1. Crude mortality rate due to myocardial infarction in the general population in Argentina (period 1991-2005). Estimated from data of the Office of Statistics and Health Information, Ministry of Health and Social Services. P value corresponds to linear regression adjustment.

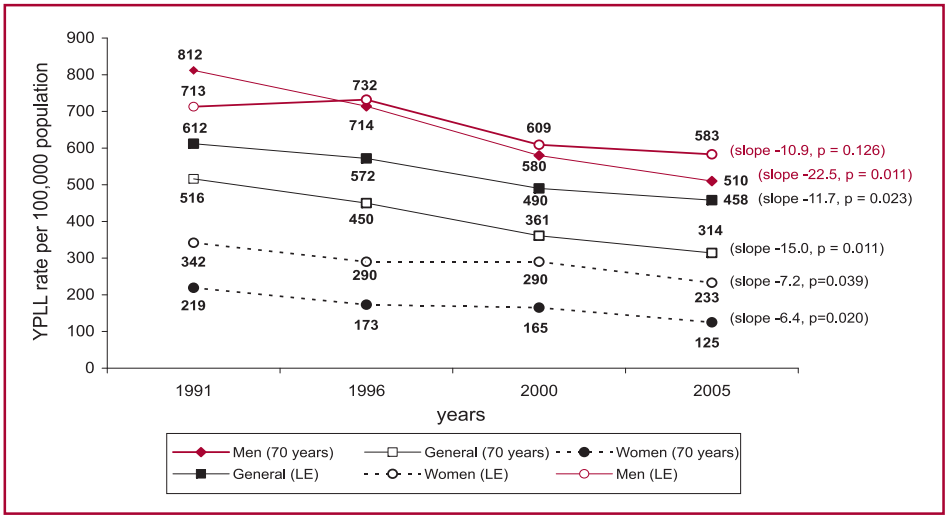

Fig. 2. Years of potential life lost rate (YPLL) per 100,000 population due to myocardial infarction in Argentina (period 1991-2005) considering an upper age limit of 70 years or life expectancy at birth (LE). Data for general population and for both genders. Estimated from data of the Office of Statistics and Health Information, Ministry of Health and Social Services. P values correspond to linear regression adjustment.

Table 1. PData if the population analyzed divided in periods of five years (1991, 1996, 2000 and 2005), with the number of deaths and the total study population retrieved from the Office of Statistics and Health Information, Ministry of Health and Social Services (DEIS) and from the Argentine Society of Cardiology (SAC).

	Year 1991			Year 1996			Year 2000			Year 2005		
	DEIS	SAC	Population	DEIS	SAC	Population	DEIS	SAC	Population	DEIS	SAC	Population
25-29	43	0	2,308,284	34	0	2,470,851	25	0	3,361,100	19	0	3,268,243
30-34	72	0	2,240,281	63	0	2,330,872	61	0	2,817,300	50	1	2,732,927
35-39	180	0	2,140,244	144	0	2,198,005	148	0	2,465,400	98	2	2,398,695
40-44	348	1	1,920,302	299	3	2,076,118	305	0	2,319,100	194	0	2,261,291
45-49	527	2	1,672,560	574	2	1,851,125	499	0	2,178,100	435	4	2,119,022
50-54	832	4	1,507,348	849	2	1,612,718	894	1	2,043,100	699	5	1,975,521
55-59	1,224	7	1,414,031	1,070	1	1,431,430	1,058	3	1,802,800	1,028	3	1,722,476
60-64	1,801	6	1,299,842	1,502	7	1,313,616	1,406	3	1,546,100	1,340	6	1,449,366
65-69	2,104	7	1,075,279	1,970	9	1,173,710	1,861	5	1,343,900	1,567	6	1,221,234
Total	**7,131**	**27**	**15,578,171**	**6,505**	**24**	**16,458,445**	**6,257**	**12**	**19,876,900**	**5,430**	**27**	**19,148,775**

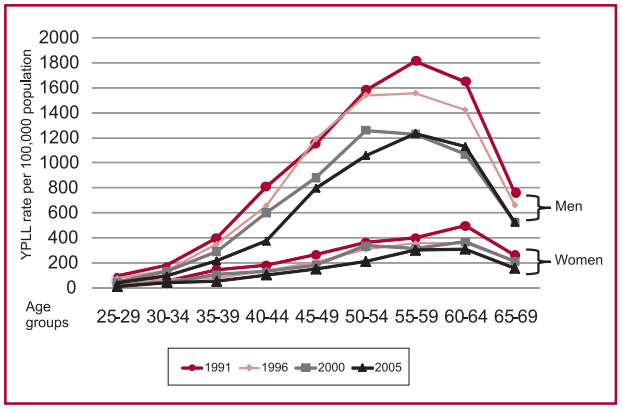

Fig. 3. Distribution of years of potential life lost (YPLL) due to myocardial infarction by 5-year age groups divided by gender during the period 1991-2005 Estimated from data of the Office of Statistics and Health Information, Ministry of Health and Social Services.

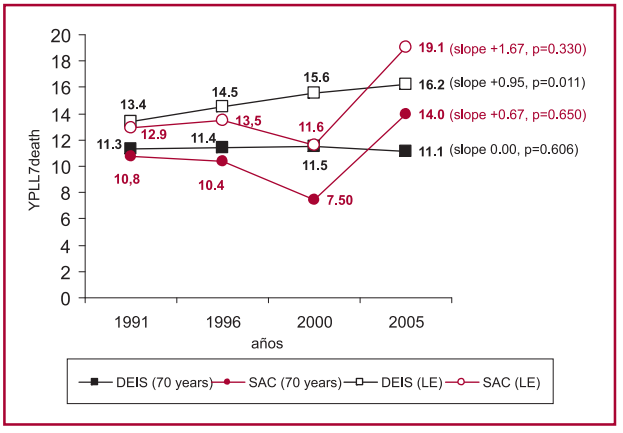

Fig. 4. Average years of potential life lost rate (YPLL) per 100,000 population due to myocardial infarction considering both methods: an upper age limit of 70 years or life expectancy at birth (LE). Estimated from data of the Office of Statistics and Health Information, Ministry of Health and Social Services(DEIS) and the SAC registries. P values correspond to linear regression adjustment.

Again, comparison between DEIS and SAC registries showed statistically significant differences only during the year 2000. In turn, sensitivity analysis demonstrated a significant increase in AYPLL from DEIS data calculated using the formula of Romeder and McWhinnie compared to AYPLL estimated with LE; however, no differences were observed from the SAC registries, probably due to the small size of the sample. Finally, Table 2 shows that there were no gender-related differences in AYPLL due to AMI when both study groups were compared using Romeder and McWhinnie's method. In this case the absence of overlap between 95% CI in women is observed only during the year 2000 ($p < 0.05$), which may be probably due to the small number of patients in the age group studied (25 to 69 years) in the SAC registries. It should be considered that the number of patients included in the SAC registries (8) in 1991, 1996, 2000 and 2005 were 526, 645, 298 and 515, respectively, and 68%, 69%, 73% and 67% were younger than 70. In addition, the number of decedents in this age group was 27 patients in 1991, 24 in 1996, 12 in 2000 and 27 in 2005 (see Table 1).

	1991	1996	2000	2005	slope
Women SAC	8.2 (2.45-14.0)	10.1 (3.22-19.0)	3.8 (1.63-5.87)	12.5 (2.51-22.5)	+0.66
Women DEIS	10.2 (9.78-10.6)	10.2 (9.70-10.6)	10.1 (9.71-10.6)	10,1 (9.64-10.6)	0.0
Men SAC	11.8 (8.95-14.5)	10.1 (6.31-14.0)	9.4 (5.94-12.8)	14.3 (10.4-18.3)	+0.68
Men DEIS	11.6 (11.4-11.8)	11.7 (11.5-12.0)	11.9 (11.6-12.1)	11.3 (11.1-11.6)	0.0

Table 2. Comparison of average years of potential life lost (YPLL) due to myocardial infarction between data from the Office of Statistics and Health Information, Ministry of Health and Social Services (DEIS) and SAC registries according to gender during the period 1991-2005. Values correspond to averages and 95% confidence intervals; a p value < 0.05 was considered in absence of confidence intervals overlap, as in the case of SAC women versus DEIS women in 2000.

DISCUSSION

The concept of premature mortality carries a preventive connotation, as most deaths occurring before a certain age might indicate deficiencies to prevent and to treat the problem. In this context, premature mortality may be interpreted as the consequence of lost opportunities in prevention, and its comparison may express an unequal influence of determinants of health and inequity in the access to health care services. (15)

This study showed that estimation of AYPLL demonstrated a lack of reduction in premature deaths for AMI in Argentina despite a reduction in crude mortality rates due to AMI from 1991 to 2005.

The concept of YPLL was first introduced by Dempsey in 1947 in order to measure the changes in mortality due to tuberculosis, and to compare it with deaths related to heart diseases and cancer using life expectancy at birth. In 1950, Haenszel (16) compared five different ways of measuring YPLL. He observed that conventional standardized death rates did not permit sufficient weight to be given to the differences in mortality at younger ages, and proposed a mortality index that could express deaths in terms of years of life lost. He used the difference between an upper limit age of 75 years and age at death. In 1951, Doughty (17) used Haenzel's method but considered an upper limit of 70 years. Finally, in 1978 Romeder and McWhinnie (11) made a wide and detailed review of the methods used for estimating YPLL, crude rates and age-adjusted rates using mortality data from Canada, and created a new indicator that considered the number of deaths at each age between 1 and 70. This method excludes deaths among aged people and infant mortality, as most cases of infant mortality are due to causes specific to this early period of life. (15)

We decided to estimate YPLL using the formula by Romeder and McWhinnie not only because it is used worldwide but also because it is the method employed by the DEIS. Obviously other fixed ages (65-75 years) or LE which was 72.1, 73.1, 74.1 and 75.1 years for the years studied (1991, 1996, 2000 and 2005, respectively) may be used; in fact, sensitivity analysis was performed using these ages.

One of the most important characteristics of YPLL is their capacity to express not only the number of deaths and percentages related to each gender, but also the prematurity of these deaths. The main goal of this study was to compare national data regarding AMI, versus the information retrieved from the SAC registries; for this reason we used AYPLL per decedent as the SAC registries only count with partial data of the country.

The statistical properties of YPLL have not been deeply examined; thus, we were not able to perform comparisons with data from other populations.

It should be noted that, for populations with long life expectancy, it is not advisable to choose low age limits in order to avoid not including age groups or causes of death which might provide important information related to health status of the elder; conversely, it is recommended to use 65 years as age limit in populations with lower life expectancy. The use of LE as an age limit for the YPLL adjusts the calculation to the population profile of the country or area. As we have previously mentioned, the problem with this approximation is that the YPLL will not be comparable with that of other populations with different life expectancies.

Although no indicator is strong enough to assign priorities or values to human life, this study tries to show the loss premature mortality means to society in terms of productivity during different stages of life estimated by YPLL. (18)

The procedure used by YPLL is not free from criticism. Some authors state that each death should also be considered independently of age, and that the number of deceased persons should be the variable used to determine the main causes of death, although it emphasizes the causes of death in old age, a stage of life were more deaths occur. Anyway, although each

human life should have the same intrinsic worth, determination of priorities based on YPLL is essential due to limitation in health resources. (19)

Finally, determination of YPLL should be taken as a complement for the investigation of the causes of death, considering the economic impact of a death from an accident may differ greatly from the same individual's death from a long-standing disease.

Study Limitations

Data from the DEIS used to estimate YPLL were obtained from death certificate diagnoses which may show discrepancies with the real causes of death, especially in cardiovascular disease as the PRISMA study has demonstrated. (20) The causes of death from the SAC registries have been clearly established; however, these data were supplied by few public and private hospitals and the sample size was small. For this reason, comparisons were performed using AYPLL. Nevertheless, one limitation for using this indicator is that the average value might not be representative of the age distribution shown in Figure 3 due to the left asymmetry seen in all the years. Anyway, AYPLL is an acceptable indicator to describe average YPLL. Finally, sensitivity analysis demonstrated that the results might be different depending on the method employed: the formula of Romeder and McWhinnie versus LE.

CONCLUSIONS

This study compared the development of deaths due to AMI in Argentina throughout the years and the YPLL as indicator of premature mortality, according to national data from the DEIS and SAC registries. Estimation of AYPLL demonstrated a lack of reduction of premature deaths for AMI in Argentina despite reductions in crude mortality rates due to AMI and in YPLL per 100,000 population from 1991 to 2005. In spite of study limitations, AYPLL serves as indicator of premature deaths due to AMI.

SUMMARY

Años de vida perdidos por infarto agudo de miocardio en la Argentina entre 1991 y 2005

Introducción
Los años potenciales de vida perdidos (APVP) son uno de los indicadores utilizados para determinar las muertes tempranas. A diferencia de las tasas de mortalidad, crudas y ajustadas por edad, este indicador, que cuantifica los años que teóricamente una persona deja de vivir si la muerte se presenta en forma prematura (o sea antes de cumplir su esperanza de vida), da una visión más amplia de la importancia relativa que tienen las causas más relevantes de mortalidad prematura, por lo que su uso se justifica en la planificación y en la definición de prioridades en salud.

Objetivos
Describir la evolución de la mortalidad por infarto agudo de miocardio (IAM) en términos de tasas de mortalidad (TM) y de años potenciales de vida perdidos (APVP) para el período 1991-2005, identificar diferencias en relación con el sexo y comparar la media de APVP por muerto (MAPVP) entre los registros SAC y los de la Dirección de Estadística e Información de Salud del Ministerio de Salud y Acción Social (DEIS).

Material y métodos
Las defunciones por IAM, distribuidas por edad y sexo, se obtuvieron de la DEIS y de los registros SAC. Los APVP se calcularon según la fórmula de Romeder y Mc Whinnie y también sobre la base de la esperanza de vida al nacer, además de la MAPVP con su intervalo de confianza del 95%.

Resultados
La TM por IAM según la DEIS descendió de 50 en 1991 a 38 por 100.000 habitantes en 2005 (pendiente [*slope*] -3,7; $p < 0,001$). La tasa de APVP disminuyó de 516 a 314 años por 100.000 en igual período. A nivel nacional, la MAPVP fue de 11,3 (11,1-11,5), 11,4 (11,2-11,6), 11,5 (11,3-11,7), 11,1 (10,8-11,3) para 1991, 1996, 2000 y 2005, respectivamente (pendiente 0,0). Se observaron resultados similares a los de la SAC –10,8 (8,22-13,5), 10,4 (6,86-14,0), 7,50 (4,67-10,3), 14,0 (10,3-17,7)– para los años mencionados (pendiente +0,67). En relación con el sexo tampoco hubo diferencias, excepto para el caso de las mujeres en el año 2000 ($p < 0,05$).

Conclusiones
El uso de la MAPVP permitió demostrar que no existiría disminución de la muerte prematura por IAM en la Argentina, lo cual no es perceptible cuando sólo se analiza la TM, que muestra una reducción en el período estudiado.
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Palabras clave > Infarto de miocardio - Años potenciales de vida perdidos - Epidemiología

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APPENDIX

– Crude mortality rate: (MR)

$$MR = \frac{\text{total number of deaths per time interval}}{\text{Total population}} \times 100{,}000 \text{ population}$$

– Years of potential life lost (YPLL):

$$YPLL = \Sigma\, Ai\, Di$$

i = age interval considered.
Ai = difference in years between the class mark *i* and the remaining years to live until age 70 when death occurs in that age interval or until life expectancy.
Di = number of deaths due to AMI in each age interval *i*.

– Years of potential life lost rate (YPLLR):

$$YPLLR = \Sigma\, Ai\ Di\ \frac{100{,}000}{N}$$

N = number of people in the upper and lower age limits.

– Average years of potential life lost (AYPLL):

$$AYPLL = YPLL / \text{number of decedents}$$

– Simple linear regression equation (slope estimation)

$$Y = \beta_0 + \beta_1 x$$

β_0 = point at which the regression line crosses the Y-axis
β_1 = slope of the line that indicates how the expected value of Y increases with each rise of X:

$$\beta_{1=} \quad \frac{\Sigma\, xy - \bar{y}\, \Sigma x}{\Sigma\, x^2 - \bar{x}\, \Sigma x}$$