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# Effect of healthcare on mortality: trends in avoidable mortality in Umbria, Italy, 1994-2009

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**Abstract**

***Objective***. Avoidable mortality trends over the period 1994-2009 were calculated to evaluate health intervention by the health system of Umbria, a region of central Italy.

***Materials and methods***. Mortality data were supplied by the regional causes of death registry. Rates were standardized to the 2001 census Italian population. Joinpoint regression was used to analyze the trends.

***Results***. Overall avoidable mortality rates decreased significantly both in males (-3.9% per year) and in females (-3.6% per year). Mortality rates from ischemic heart and cerebrovascular disease about halved in the study period in both sexes. Avoidable mortality increased slightly only for a few causes (*e.g.* lung cancer in females).

***Conclusion***. The overall trend of avoidable mortality indicates that the regional health/preventive system is performing well.

**Key words**
- health system
- evaluation studies
- mortality

## INTRODUCTION

Life expectancy in Umbria, a region of Italy has been steadily increasing over the last decades, as in Italy and in other developed countries, due to falling death rates across all ages, especially in the young [1, 2]. In Umbria, the median age of death varied, over the 1994-2009 period, from 79 to 80 in males, and from 83 to 85 in females, and the mean age of death varied from 74 to 77 in males, and from 77 to over 84 in females [1, 2]. The fact that the mean increased more than the median age of death is the consequence of decreasing mortality among youngs and adults, particularly in females [1].

This paper examines the extent to which healthcare contributed to this trend. This is possible by examining trends in avoidable mortality, a concept that refers to premature deaths from certain conditions that are considered to be largely avoidable given timely and effective healthcare [3]. In most of the countries or regions studied, the only exemptions come from Eastern Europe, avoidable mortality rates have fallen gradually over recent decades and at a faster rate than mortality from non-avoidable causes, suggesting that healthcare has had a definite impact on mortality [4-10]. Defined in this way, avoidable mortality does not include all deaths potentially avoidable from any intervention, but only those deaths with causes amenable to prevention or treatment through the healthcare system and/or through health-related policies [11].

Over the years, several authors proposed different sets of criteria for defining groups of mortality causes to be considered as avoidable, with arduous national and international comparisons [12-21]. For this last point it could be important to agree on an international standard list of avoidable mortality.

Following the International Classification of Diseases (ICD-10) [22], Korda and Butler [12] classified deaths into three categories (Medical care indicators: MCI; health policy indicators: HPI; ischemic heart disease: IHD), following the classification of avoidable mortality by Nolte *et al.* [3, 20], and defined MCI conditions those having identifiable effective interventions that are administered by health providers; HPI causes are those where death is mainly avoidable not via medical interventions but through primary prevention (education interventions) reflecting national health-related policies and include cross sectoral interventions (health promotion interventions); IHD are separately considered because of the large number of deaths that probably obscure the contribution of other causes in MCI category. Gispert *et al.* [19] modified the above classification adding and removing causes. Other authors classified avoidable mortality in three different categories: deaths avoidable by primary prevention, by screening and therapy, and by medical care and health policy

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[2, 17, 18]. Stirbu *et al.* grouped avoidable causes independently from medical interventions: diseases of infectious origin, suicides, malignant diseases, acute and chronic conditions, conditions related to maternity and neonatal period [21].

In this paper we examine recent trends in avoidable and non-avoidable mortality in Umbria in the period 1994 and 2009, based on a modified list of Korda *et al.* [12], with the aim to estimate the contribution of the regional healthcare system in declining both, avoidable and non, mortality rates over the past fifteen years. The focus of the analysis will be on overall and cause specific avoidable mortality rates and we will not force causes of death into arbitrary and often overlapping groups defined by health intervention level.

## METHODS

We used anonymous mortality data from the Cause of Death Nominative Registry (ReNCaM) of the Umbria region. ReNCaM is a regional mortality registry based on lists of deceased from the databases of Umbrian municipalities, supplemented by death certificates which report the cause of death. This data has been regularly collected since 1994.

To calculate the avoidable mortality rate we modified the list proposed by Korda *et al.* [4] including deaths aged 0-74 from upper aero digestive tract cancers (C00-C15), liver (C22) and larynx (C32) cancers; deaths aged 14-74 from chronic lower respiratory diseases (J40-J47); all deaths from mental and behavioral disorders due to use of alcohol and psychoactive substances (F10-F19), suicide (X60-X84) and homicide (X85-Y09). Because of the impossibility to assign some diseases only to a single category, we preferred to list the avoidable disease into a unique group, as reported in *Table 1* for males and *Table 2* for females.

For each cause we calculated, for the periods 1995-1999 and 2005-2009, the age-adjusted mortality rates (AADR) using males + females census 2001 Umbrian population as standard, for all causes of death, in males and females, aged both 0-74 and 0-85+. The age limit imposed (74 years for most causes) for AADR of avoidable causes is justified by the actual higher median age of death with respect to the formerly considered limit (64) [2]. The avoidable deaths from "disorders due to alcohol and psychoactive substances" and from examined "external causes" were referred to all ages. The age range of "all respiratory diseases" varies from 0 to 14, considering that perinatal mortality from these pathologies is elsewhere listed.

A generalized linear model (GLM) regression was fitted to our data for the periods 1995-1999 and 2005-2009 using glmfit and glmvalMatlab functions setting poisson distribution and log link [23]. We evaluated the mortality rate ratios (MRR) that are the exponentiated coefficients and the corresponding confidence intervals [8].

Sex and cause-specific trends for standardized mortality rates were analyzed by *joinpoint regression*, using SEER software, over the 1994-2009 period [24, 25]. The Umbrian population was used as standard in the joinpoint analyses, with the aim to reduce the bias due to age structure.

The mortality trend over the study period is approximated by one or more straight segments. A joinpoint occurs when a significant change in trend is detected by the grid search method, that is before and after the joinpoint the two line segments have different slopes. Trends are described by the period corresponding *(Table 3)* to a linear segment and the expected annual percent change (EAPC) with 95% confidence interval.

## RESULTS

*Table 1* reports the age-adjusted rates from avoidable mortality in males, in Umbria, in the periods 1995-1999 and 2005-2009. Mortality rate ratios (MRR) for the study periods from a GLM model are also presented. Comparing the last *vs* the first period, the rates showed a general decrease (*i.e.* MRR < 1): all the avoidable causes decreased of 35% (MRR 0.67 with a narrow confidence interval, CI, from 0.70 to 0.65). Only a few causes had an increase and among these the "disorders due to alcohol and psychoactive substances" had a significant increase of 34% in the most recent period (MRR 1.48 with 95% CI from 1.08 to 2.03). Among the causes of death decreasing over the study time window: lung cancer (-23%), upper aero digestive tract cancers, and larynx cancer showed a significant decrease; chronic lower respiratory tract diseases (-48%), chronic liver diseases (-50%), cerebral-vascular diseases (-42%), and ischemic heart diseases (-51%) decreased significantly as well. Liver cancer mortality is decreasing but the observed variation is not significant. Some mortality causes, like skin carcinoma, testis cancer, Hodgkin's disease, diseases of the thyroid, diabetes mellitus, epilepsy, all respiratory diseases including influenza, peptic ulcer, appendicitis, abdominal hernia, cholelithiasis and cholecystitis, benign prostatic hyperplasia and, particularly, perinatal deaths and homicide have a rate less than 1 per 100 000 residents in the last period.

In females mortality from all avoidable causes decreased to a similar extent with respect to males (MRR 0.69 with 95% CI from 0.65 to 0.72) but variation by causes showed some differences. The avoidable mortality rates from ischemic heart (MRR 0.45 with 95% CI from 0.51 to 0.39) and cerebrovascular diseases (MRR 0.51 with 95% CI from 0.59 to 0.44) declined about 50%, but lung cancer mortality rose slightly (MRR 1.2 with 95% CI from 1.001 to 1.43). Larynx cancer avoidable mortality also increased but not significantly. Chronic liver disease and cirrhosis significantly decreased like among males. The cause groups which, in the last period, presented a rate less than 1, beside those above reported for males, are leukemia, disorders due to alcohol and psychoactive substances, nephritis and nephrosis, and maternal deaths *(Table 2)*.

In both sexes motor vehicle accidents decreased, showing a rate from 24.1 to 15.1 in males (MRR 0.69 with 95% CI from 0.80 to 0.60) and from 7.9 to 3.7 in females (MRR 0.54 with 95% CI from 0.70 to 0.41).

The *Figures 1-4* report the temporal trends of mortality from all causes, from all cancers, from ischemic heart disease and from external causes. The share of avoidable mortality, with respect to the all-age one, is very small for overall causes and for all cancers, whereas

**Table 1**
Age-adjusted rates (S.E.) per 100 000 from avoidable causes of death, age-adjusted mortality rate ratios, MRR, with 95% confidence intervals (p value) from a Poisson regression model. Males 1995-1999 and 2005-2009

| Cause of death | Age range | 1995-1999 | 2005-2009 | MRR | 95% CI (p) |
|---|---|---|---|---|---|
| All avoidable causes | | 348.15 (4.32) | 227.31 (3.43) | **0.67** | **0.65-0.70 (0.000)** |
| Infectious diseases (excl. obstet. and neonat. tetanus) A00-A32, A35-B99 | 0-74 | 7.34 (0.64) | 6.06 (0.57) | 0.86 | 0.67-1.11 (0.274) |
| Upper aerodigestive tract cancers C00-C15 | 0-74 | 10.79 (0.79) | 7.03 (0.62) | **0.67** | **0.54-0.85 (0.001)** |
| Colorectal cancer C18-C20 | 0-74 | 26.64 (1.23) | 23.15 (1.14) | 0.88 | 0.77-1.01 (0.078) |
| Liver cancer C22 | 0-74 | 14.33 (0.91) | 12.89 (0.85) | 0.91 | 0.76-1.09 (0.335) |
| Larynx cancer C32 | 0-74 | 5.68 (0.57) | 3.33 (0.43) | **0.60** | **0.43-0.83 (0.002)** |
| Trachea, bronchus and lung cancer C33-C34 | 0-74 | 70.89 (2.01) | 54.73 (1.75) | **0.79** | **0.72-0.86 (0.000)** |
| Skin carcinomas C44 | 0-74 | 0.58 (0.18) | 0.22 (0.11) | 0.40 | 0.12-1.27 (0.121) |
| Testis cancer C62 | 0-74 | 0.23 (0.11) | 0.11 (0.07) | 0.50 | 0.09-2.72 (0.423) |
| Hodgkin's disease C81 | 0-74 | *0.62 (0.19)* | *0.71 (0.20)* | *1.18* | *0.52-2.63 (0.683)* |
| Leukaemia C91-C95 | 0-44 | 2.59 (0.50) | 1.50 (0.37) | 0.62 | 0.34-1.15 (0.135) |
| Disease of the thyroid E00-E07 | 0-74 | 0.12 (0.08) | 0.00 (0.00) | - | - |
| Diabetes mellitus E10-E14 | 0-49 | 0.70 (0.25) | 0.51 (0.19) | 0.87 | 0.31-2.41 (0.796) |
| Disorders due to alcohol and psychoactive substances F10-F19 | All | *3.24 (0.44)* | *4.34 (0.45)* | ***1.48*** | ***1.08-2.03 (0.01)*** |
| Epilepsy G40-G41 | 0-74 | *0.17 (0.10)* | *0.42 (0.15)* | *2.66* | *0.70-10.0 (0.14)* |
| Chronic rheumatic heart disease I05-I09 | 0-74 | 1.83 (0.32) | 1.18 (0.26) | 0.65 | 0.37-1.13 (0.134) |
| Hypertensive disease I10-I13, I15 | 0-74 | 9.47 (0.74) | 6.49 (0.60) | **0.71** | **0.56-0.90 (0.005)** |
| Ischemic heart disease I20-I25 | 0-74 | 100.24 (2.39) | 49.00 (1.65) | **0.50** | **0.46-0.54 (0.000)** |
| Cerebrovascular disease I60-I69, G45 | 0-74 | 44.79 (1.60) | 25.78 (1.21) | **0.58** | **0.52-0.65 (0.000)** |
| All respiratory diseases (excl. influenza) J00-J06, J20-J99 | 0-14 | 0.00 (0.00) | 0.70 (0.50) | - | - |
| Influenza J10-J11 | 0-74 | 0.41 (0.15) | 0.06 (0.06) | 0.14 | 0.01-1.16 (0.069) |
| Chronic lower respiratory tract J40-J47 | 15-74 | 18.66 (1.12) | 9.63 (0.80) | **0.51** | **0.42-0.63 (0.000)** |
| Peptic ulcer K25-K27 | 0-74 | 1.74 (0.32) | 0.53 (0.17) | **0.3** | **0.14-0.63 (0.002)** |
| Appendicitis K35-K38 | 0-74 | 0.06 (0.06) | 0.00 (0.00) | - | - |
| Abdominal hernia K40-K46 | 0-74 | 0.24 (0.12) | 0.17 (0.10) | 0.75 | 0.16-3.35 (0.70) |
| Chronic liver disease and cirrhosis K70, K71.7, K73-K74, K76.0 | 0-74 | 20.08 (1.07) | 10.09 (0.75) | **0.52** | **0.43-0.62 (0.000)** |
| Cholelithiasis and cholecystitis K80-K81 | 0-74 | 0.63 (0.19) | 0.42 (0.16) | 0.63 | 0.24-1.64 (0.350) |
| Nephritis and nephrosis N00-N07, N17-N19, N25-N27 | 0-4 | 1.21 (1.21) | 1.02 (1.02) | 1 | 0.06-15.98 (1.0) |
| Benign prostatic hyperplasia N40 | 0-74 | 0.06 (0.06) | 0.00 (0.00) | - | - |
| Congenital cardiovascular abnorm. Q20-Q28 | 0-74 | 3.17 (0.38) | 1.17 (0.21) | 0.72 | 0.38-1.38 (0.332) |
| Perinatal deaths (excl. stillbirths) P00-P96, A33-A34 | All | 1.20 (0.25) | 0.77 (0.19) | **0.43** | **0.28-0.67 (0.000)** |
| Motor vehicle accident V01-V99 | All | 24.08 (1.35) | 15.13 (0.99) | **0.69** | **0.60-0.80 (0.000)** |
| Suicide X60-X84 | All | 15.76 (1.10) | 14.71 (1.00) | 0.97 | 0.82-1.14 (0.770) |
| Homicide X85-Y09 | All | 0.62 (0.25) | 0.37 (0.13) | 0.8 | 0.31-2.02 (0.638) |
| Surgical or medical care misadventures Y60-Y89 | All | *1.66 (0.42)* | *1.98 (0.43)* | *1.16* | *0.67-2.01 (0.579)* |

Note: in bold significant MRRs ($p < 0.05$); in italic MRRs > 1 (*i.e.* avoidable rates higher in the more recent period).

**Table 2**
Age-adjusted rates (S.E.) per 100 000 from avoidable causes of death, age-adjusted mortality rate ratios, MRR, with 95% confidence intervals (p value) from a Poisson regression model. Females 1995-1999 and 2005-2009

| Cause of death | Age range | 1995-1999 | 2005-2009 | MRR | 95% CI (p) |
|---|---|---|---|---|---|
| All avoidable causes | | 154.68 (2.64) | 105.81 (2.17) | **0.69** | **0.65-0.72 (0.000)** |
| Infectious diseases (excl. obstet. and neonat. tetanus) A00-A32, A35-B99 | 0-74 | 3.00 (0.40) | 3.65 (0.43) | 1.28 | 0.90-1.81 (0.162) |
| Upper aerodigestive tract cancers C00-C15 | 0-74 | 1.88 (0.31) | 1.69 (0.29) | 0.91 | 0.57-1.46 (0.722) |
| Colorectal cancer C18-C20 | 0-74 | 15.41 (0.88) | 13.17 (0.81) | 0.85 | 0.72-1.00 (0.059) |
| Liver cancer C22 | 0-74 | 4.91 (0.49) | 4.17 (0.46) | 0.83 | 0.62-1.12 (0.234) |
| Larynx cancer C32 | 0-74 | 0.10 (0.07) | 0.31 (0.12) | 3 | 0.60-14.86 (0.178) |
| Trachea, bronchus and lung cancer C33-C34 | 0-74 | *11.40 (0.76)* | *13.66 (0.83)* | ***1.20*** | ***1.00-1.43 (0.040)*** |
| Skin carcinomas C44 | 0-74 | 0.30 (0.12) | 0.21 (0.10) | 0.66 | 0.18-2.36 (0.530) |
| Breast cancer C50 | 0-74 | 27.34 (1.19) | 22.93 (1.07) | **0.86** | **0.76-0.98 (0.024)** |
| Cervix uteri cancer C53 | 0-74 | 1.69 (0.30) | 1.04 (0.23) | 0.65 | 0.37-1.13 (0.134) |
| Body and unsp. uterine cancer C54-C55 | 0-74 | 4.11 (0.46) | 4.29 (0.46) | 1.04 | 0.77-1.42 (0.756) |
| Hodgkin's disease C81 | 0-74 | *0.48 (0.16)* | *0.67 (0.19)* | *1.44* | *0.61-3.37 (0.396)* |
| Leukaemia C91-C95 | 0-44 | 1.97 (0.43) | 0.37 (0.18) | **0.19** | **0.06-0.55 (0.002)** |
| Disease of the thyroid E00-E07 | 0-74 | 0.31 (0.13) | 0.15 (0.09) | 0.5 | 0.12-1.99 (0.327) |
| Diabetes mellitus E10-E14 | 0-49 | 0.17 (0.12) | 0.15 (0.11) | 1 | 0.14-7.09 (1.0) |
| Disorders due to alcohol and psychoactive substances F10-F19 | All | 0.54 (0.16) | 0.54 (0.16) | 1 | 0.44-2.22 (1.0) |
| Epilepsy G40-G41 | 0-74 | 0.35 (0.13) | 0.21 (0.10) | 0.57 | 0.16-1.95 (0.372) |
| Chronic rheumatic heart disease I05-I09 | 0-74 | 2.42 (0.34) | 1.17 (0.24) | **0.46** | **0.28-.77 (0.003)** |
| Hypertensive disease I10-I13, I15 | 0-74 | 5.76 (0.53) | 3.77 (0.43) | **0.64** | **0.47-0.85 (0.003)** |
| Ischaemic heart disease I20-I25 | 0-74 | 33.03 (1.27) | 15.18 (0.87) | **0.45** | **0.39-0.51 (0.000)** |
| Cerebrovascular disease I60-I69, G45 | 0-74 | 26.44 (1.14) | 13.83 (0.83) | **0.51** | **0.44-0.59 (0.000)** |
| All respiratory diseases (excl. influenza) J00-J06, J20-J99 | 0-14 | 1.25 (0.72) | 0.70 (0.49) | 0.66 | 0.11-3.98 (0.657) |
| Influenza J10-J11 | 0-74 | *0.05 (0.05)* | *0.20 (0.10)* | **4** | **0.44-35.78 (0.21)** |
| Chronic lower respiratory tract J40-J47 | 15-74 | 4.75 (0.52) | 3.75 (0.47) | 0.77 | 0.55-1.06 (0.118) |
| Peptic ulcer K25-K27 | 0-74 | 0.41 (0.14) | 0.31 (0.12) | 0.75 | 0.26-2.16 (0.594) |
| Appendicitis K35-K38 | 0-74 | 0.05 (0.05) | 0.00 (0.00) | - | - |
| Abdominal hernia K40-K46 | 0-74 | 0.42 (0.15) | 0.05 (0.05) | **0.125** | **0.01-0.99 (0.05)** |
| Chronic liver disease and cirrhosis K70, K71.7, K73-K74, K76.0 | 0-74 | 9.83 (0.70) | 2.95 (0.38) | **0.28** | **0.21-0.39 (0.000)** |
| Cholelithiasis and cholecystitis K80-K81 | 0-74 | 0.20 (0.10) | 0.15 (0.08) | 0.75 | 0.16-3.35 (0.70) |
| Nephritis and nephrosis N00-N07, N17-N19, N25-N27 | 0-4 | 0.00 (0.00) | 0.00 (0.00) | - | - |
| Maternal deaths O00-O99 | All | *0.05 (0.05)* | *0.09 (0.06)* | ***2.28*** | ***1.87-2.77 (0.000)*** |
| Congenital cardiovascular abnorm. Q20-Q28 | 0-74 | 1.79 (0.30) | 1.19 (0.22) | 0.52 | 0.24-1.13 (0.1) |
| Perinatal deaths (excl. stillbirths) P00-P96, A33-A34 | All | 1.06 (0.24) | 0.48 (0.15) | 0.8 | 0.48-1.31 (0.379) |
| Motor vehicle accident V01-V99 | All | 7.88 (0.64) | 3.73 (0.42) | **0.54** | **0.41-0.70 (0.000)** |
| Suicide X60-X84 | All | 3.25 (0.42) | 2.73 (0.36) | 0.87 | 0.62-1.22 (0.436) |
| Homicide X85-Y09 | All | 0.51 (0.18) | 0.33 (0.13) | 0.77 | 0.28-2.08 (0.618) |
| Surgical or medical care misadventures Y60-Y89 | All | 1.24 (0.31) | 1.09 (0.25) | 1.25 | 0.69-2.25 (0.457) |

Note: in bold significant MRRs ($p < 0.05$); in italic MRRs > 1 (*i.e.* avoidable rates higher in the more recent period).

for ischemic heart disease it is close to 60% in males and to 40% in females. Relating to external causes, even if in males the total rates constantly diminished, the percent of avoidable causes remained the same (59-58%). The mortality for external causes in females showed a similar trend.

*Table 3* reports the joinpoint analysis, by sex, for those causes that showed a rate more than 10 per 100 000 inhabitants. A statically significant decrease in rate is observed for all avoidable causes of death jointly considered, and for upper aero digestive tract cancers, lung cancer, ischemic heart disease, cerebrovascular diseases and motor vehicle accidents when avoidable causes of death are considered separately one by one. In females the reduction is statically significant, among examined causes, for all avoidable causes and for cerebrovascular diseases. Lung cancer mortality presented a non-significant increasing EACP over the study period among females.

## DISCUSSION

Between 1994 and 2009, the Umbria region experienced a 35% decline in avoidable standardized mortality in males (MRR 0.67) and a 32% in females (MRR 0.69). The corresponding reduction in non-avoidable mortality was 27% among males and 25% among females.

The larger decrease of avoidable mortality in males, from 21 to 17% in general mortality, with respect to the decline in females, 15% to 14%, largely depends on the high standardized mortality rate in 1994: 1785 per 100 000 in males and 1069 in females. Indeed, the EAPC in males (-3.94) was just a bit higher than in females (-3.56) and both trends are statistically significant. The 0-74 year mortality decreased in both sexes.

The share of avoidable mortality among cancer sites varied from 29 to 26% in males and remained the same in females (29%). The overall cancer mortality was reported to be decreasing in Umbria in a previous paper over the period 1978-2004 and this favorable trend was partly explained by the decreasing trend for avoidable cancers mortality [26]. Considering specific cancers sites, colorectal cancers, in males over the 1994-2009 period, the EAPC showed a non-significant increase of 1.25%; in females the trend frequently varied with a visible, but not significant, decline after 2007 (-11.75%). This tendency in part can be due to the introduction, in 2006, of the FOBT-based population screening and to the improvement of therapeutic interventions [27]. A similar consideration can be made regarding breast cancer in females. In this case the statistically significant EAPC is equal to -2.02. In the Umbria region the population screening for this cancer was introduced in 1998 [28].

Avoidable mortality from uterine cervix cancer is close to zero. Even in this case it seems that the screening, first introduced as an opportunistic intervention in the 1970's and then changed in population-based program

**Table 3**
Joinpoint analysis by sex from selected causes* in the Umbria region. 1994-2009**

| Cause of death | Age range and sex | Period | EAPC | 95% CI |
|---|---|---|---|---|
| All avoidable causes | M | 1994-2009 | **-3.94** | -4.40/-3.47 |
| | F | 1994-2009 | **-3.56** | -4.05/-3.06 |
| Upper aerodigestive tract cancers C00-C15 | 0-74 M | 1994-2009 | **-4.07** | -6.06/-2.04 |
| Colorectal cancer C18-C20 | 0-74 M | 1994-2009 | 1.25 | -0.14/2.66 |
| | | 1994-1999 | 4.39 | -0.46/9.47 |
| | | 1999-2002 | -5.80 | -23.79/16.43 |
| | | 2002-2007 | 4.03 | -2.83/11.37 |
| | | 2007-2009 | -11.75 | -29.24/10.07 |
| | F | 1994-2009 | 1.25 | -0.14/2.66 |
| | | 1994-1999 | 4.39 | -0.46/9.47 |
| | | 1999-2002 | -5.80 | -23.79/16.43 |
| | | 2002-2007 | 4.03 | -2.83/11.37 |
| | | 2007-2009 | -11.75 | -29.24/10.07 |
| Liver cancer C22 | 0-74 M | 1994-2009 | -0.93 | -1.97/0.12 |
| Trachea, bronchus and lung cancer C33-C34 | 0-74 M | 1994-2009 | **-2.34** | -2.84/-1.83 |
| | F | 1994-2009 | 2.19 | 0.73/3.67 |
| Breast cancer C50 | 0-74 F | 1994-2009 | **-2.02** | -3.04/-1.00 |
| Ischemic heart disease I20-I25 | 0-74 M | 1994-1999 | 0.61 | -3.65/5.06 |
| | | 1999-2009 | **-8.33** | -10.03/-6.60 |
| | F | 1994-1999 | -0.38 | -5.14/4.61 |
| | | 1999-2009 | **-9.01** | -11.02/-6.95 |
| Cerebrovascular disease I60-I69, G45 | 0-74 M | 1994-2009 | **-5.76** | -7.23/-4.27 |
| | F | 1994-2009 | **-6.61** | -8.07/-5.13 |
| Motor vehicle accident V01-V99 | All M | 1994-2004 | -1.57 | -4.74/1.70 |
| | | 2004-2009 | **-11.80** | -21.25/-1.21 |
| Suicide X60-X84 | All M | 1994-2009 | -1.93 | -4.29/0.48 |

*Showing rates over 10 per 100 000 inhabitants; **Only significant joinpoints ($p < 0.05$) were retained in final models for each cause.; EAPC: expected annual percent change.
Note: in bold significant EAPCs.

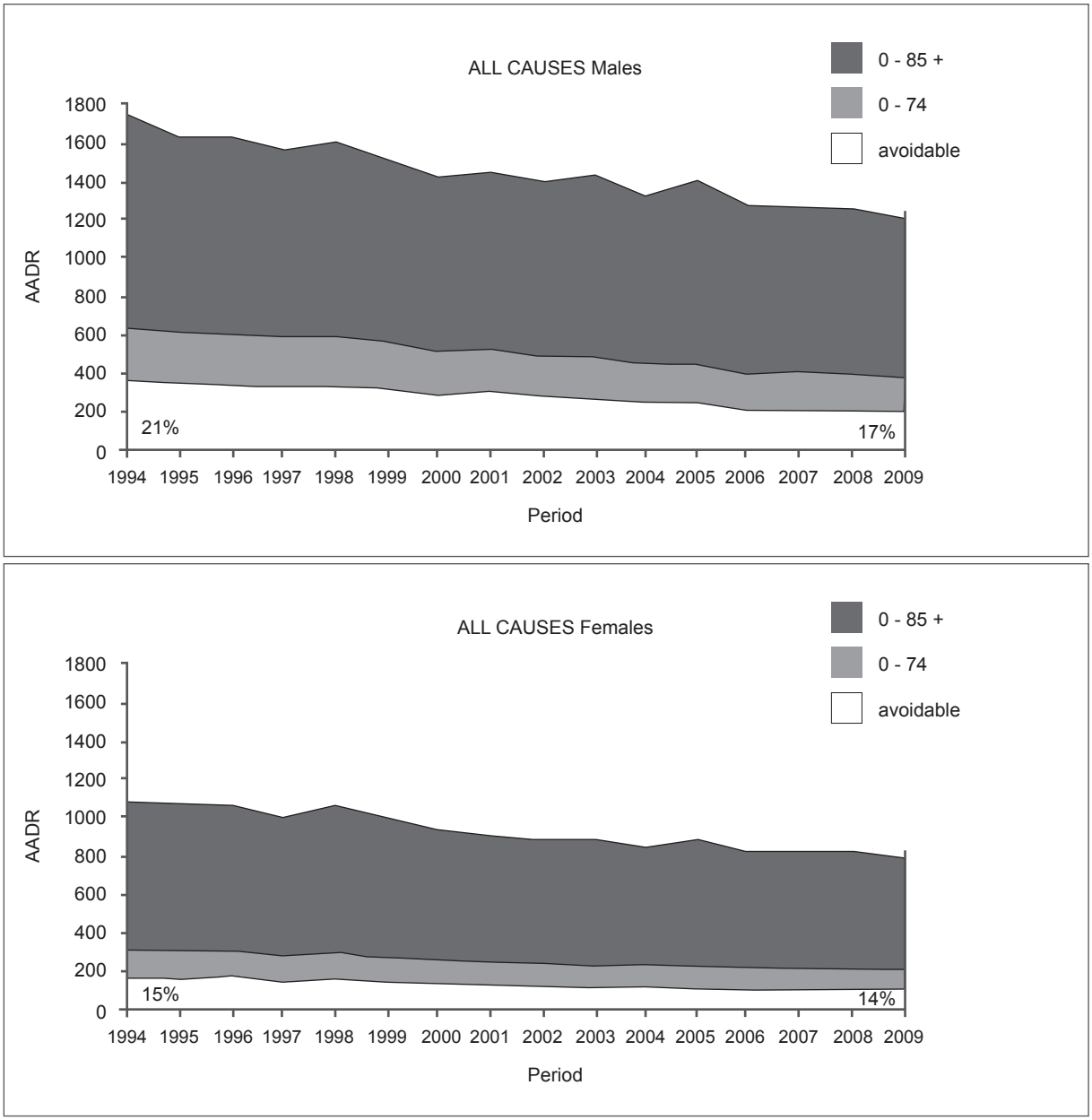
in 1998, lead to a dramatic mortality reduction [29].

It is possible that a share of cervix uteri mortality is included among unspecified uterus cancer mortality: however, in the Umbria region in 2008, the overall number of new cases of cervix cancer registered was 35, corresponding to a standardized rate of 7.4 per 100 000, whereas the rate from cancer of uterine body was 23.9 [30]. Thus unspecified uterus cancer mortality is likely to be due mainly or almost entirely to cancer of the corpus.

The avoidable mortality from upper aero digestive tract cancers in males (EAPC = -4.07) showed a clear reduction, probably due to lifestyle changes (decreased exposure to cigarette smoking and alcohol consumption) [31, 32]. This trend is also confirmed by the avoidable mortality from lung cancer that significantly decreased in males (EAPC = -2.34) and, on the contrary, increased in females (EAPC = 2.19). The Umbrian regional cancer registry reported similar trends in incidence [30]. Among females avoidable causes of death strictly associated with tobacco consumption (*e.g.* lung cancer, larynx cancer) increased [31, 32]. The other causes linked to alcohol consumption and other risk factors were stable or decreasing (*e.g.* upper aero digestive tract cancer, liver cancer, chronic liver disease and cirrhosis) [33].

The share of avoidable mortality from ischemic heart disease regards all population aged 0-74, and still constitutes a high percentage of the total mortality (58.56% in males and 36.90% in females, in the last year), even if a reduction trend is present since 1994 (from 71.9 and 59.9% respectively in males and in females). Be-

**Figure 1**
Mortality trend from all causes (A00-Z99) by gender, 1994-2009




AADR: age-adjusted mortality rates.

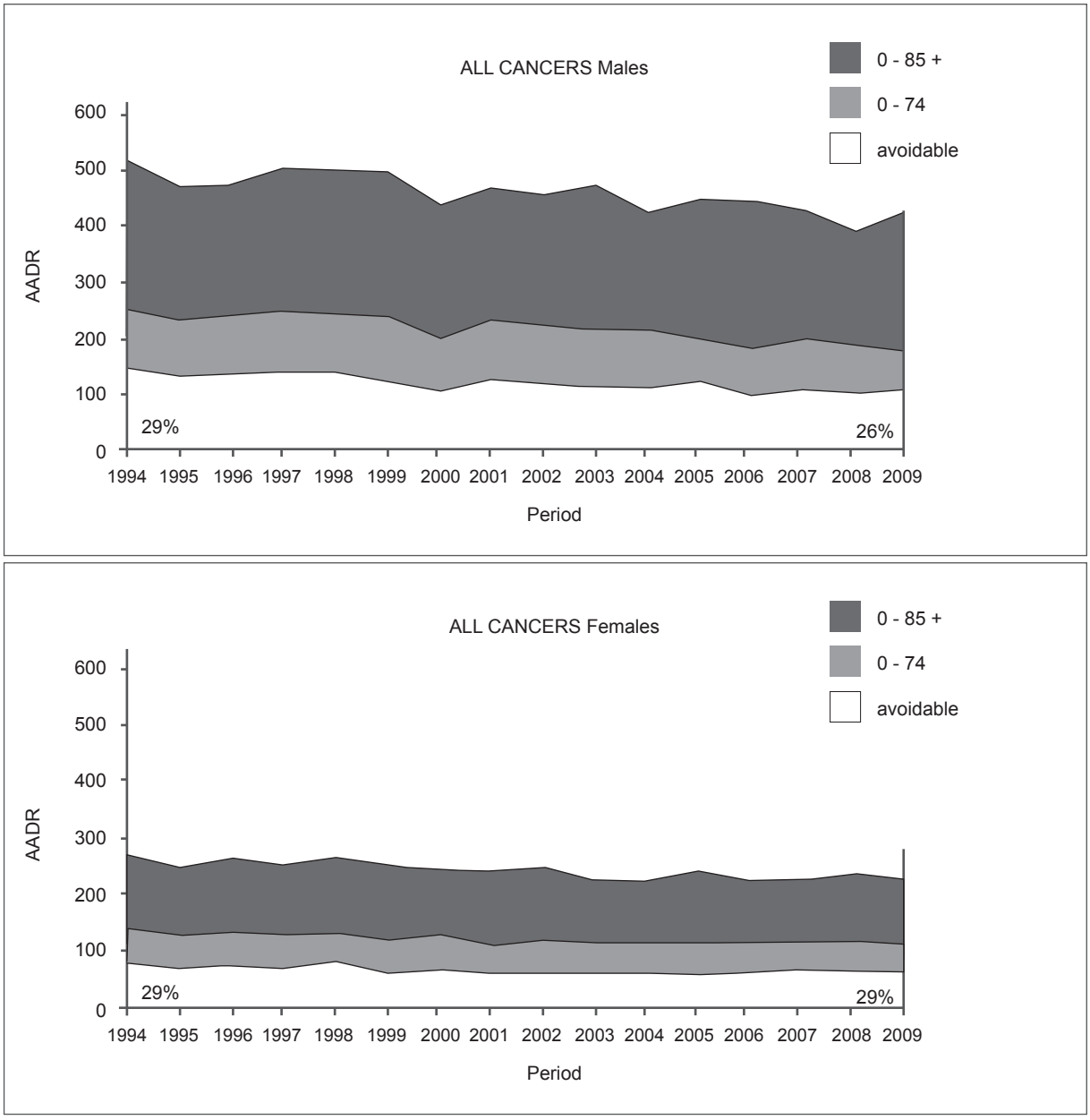
cause incidence data for ischemic heart disease is not available, it is difficult to disentangle the role of primary prevention and early therapeutic interventions. However the reduction of the number of cigarette smokers, as emphasized for upper aero digestive and lung cancers, and dietary risk factors influenced, together with medical treatment of hypertension and hypercholesterolemia, the observed reduction in rates [11].

For cerebrovascular diseases, healthcare interventions contributed to the noticeable decrease in mortality. The drug therapies finalized in controlling risk conditions, such as hypertension and hypercholesterolemia, or preventing stroke recurrence by anticoagulant therapy, and the establishment of stroke units, contributed to the decline in avoidable mortality [11].

The overall mortality from external causes nearly halved over the period, particularly in males, from 88.34 to 49.17 per 100 000 residents. In particular a great share of this decrease among males was a consequence of declining death rates due to motor vehicle accidents (significant EACP = -11.80) since 2004. That is a consequence of structural and education interventions regarding road security, alcohol and speed control, and use of seatbelt and airbag and to helmet use by motorcyclists [34]. As expected, because of the attention this population group has had on the priority list since the creation on the national health system, perinatal deaths present a low rate.

At last, we must point out the inadequate reduction trend of suicide in males. Almost no reduction was observed for this cause of death and the standardized rate relative to the 2005-2009 periods is very close to the

**Figure 2**
Mortality trend from all causes (C00-C99) by gender, 1994-2009



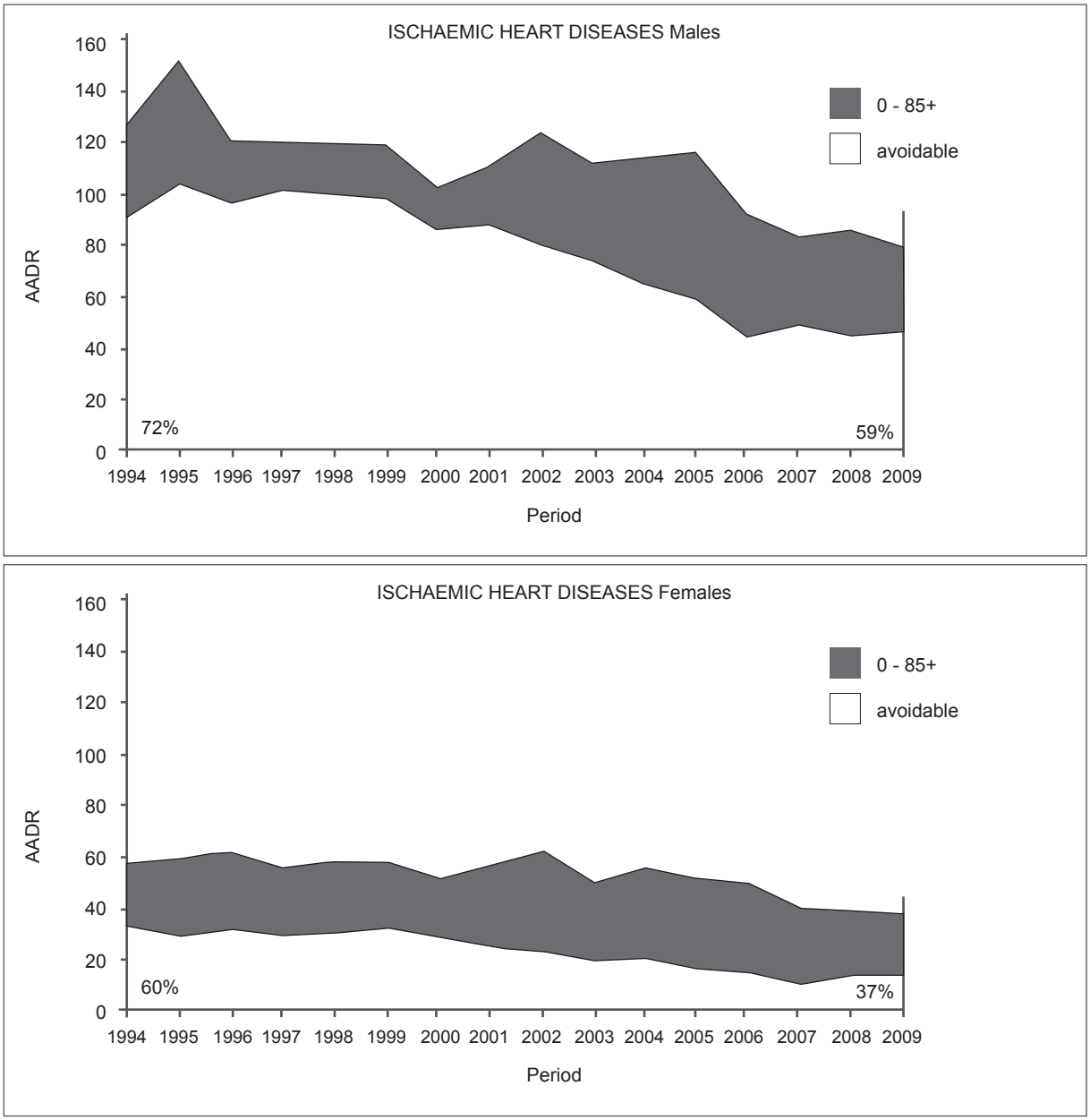

AADR: age-adjusted mortality rates.

one from motor vehicle accidents (14.7 *vs* 15.1 per 100 000). The rate of homicides is low in both sexes.

If we look at the percentage of avoidable causes over general causes of deaths, we can see that avoidable causes are responsible for more than half of mortality due to ischemic heart disease in both sexes and deaths due to external causes among males and of a small share of cancer mortality. However, when we look at the change of the percentage of mortality due to avoidable causes over time, it is of note that the percentage of avoidable mortality is markedly decreased for ischemic heart diseases in both sexes and deaths due to external causes among males only whereas it is stable for cancer deaths (*i.e.* cancer deaths not included among avoidable causes decreased to a similar extent with respect to avoidable cancer deaths).

This study shows an overall decline in avoidable mortality, together with a decline of general mortality for all ages. A possible explanation for this finding is that the regional Umbrian healthcare system is performing well. Two national atlases of avoidable mortality in Italy, examining mortality data relative to the period 1996-2002, gave evidence of both, high ranking of Umbria among Italian regions, and steeply improving trend over the study period [35, 36]. The role of the regional health system in determining trends for risk factors such as tobacco smoking and alcohol consumption is rather limited and trends strongly depend on external factors (*e.g.* media campaign, pricing policies, laws). However programmed screenings have been introduced for breast cancer, cervix uteri

**Figure 3**
Mortality trend from ischemic heart diseases (I20-I25) by gender, 1994-2009



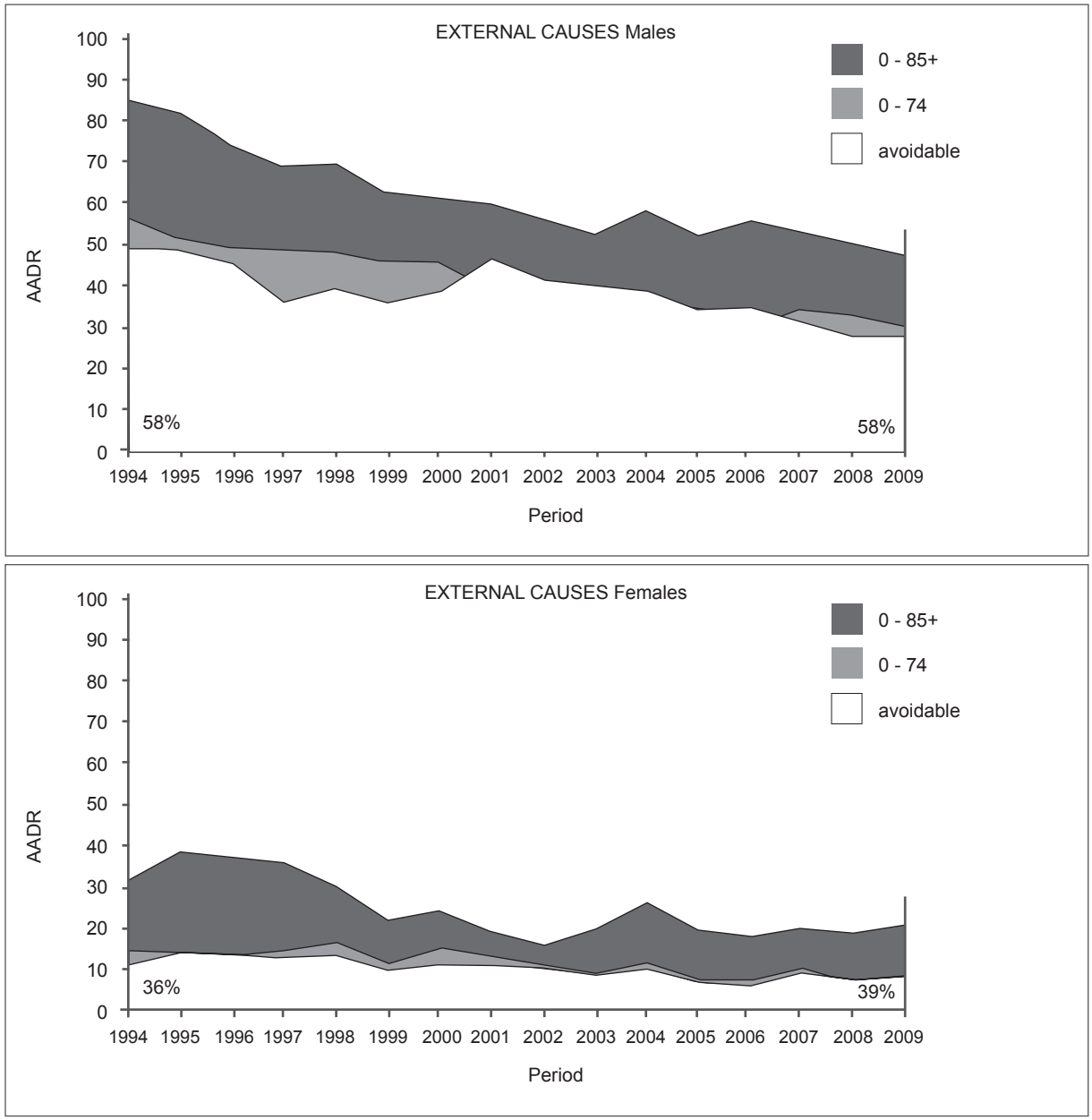

AADR: age-adjusted mortality rates.

(started in 1998) and large bowel (2006). Opportunistic screening is also diffused for prostate cancer and skin melanoma [37]. Health system interventions and non health measures (*e.g.* road surveillance, safe road building, renewed car parks) have been implemented to improve motor vehicle accidents. Relevant initiatives to evaluate health interventions and improve outcomes were introduced for cancer and cardio-vascular diseases [38-40]. In general, between the years 2000 and 2003, an evaluation of health determinants and health system policy was performed in the region that involved all regional experts and health professionals; this produced the revision of several intervention protocols, guide lines, quality criteria, and health prevention campaigns [41, 42].

## CONCLUSIONS

The studies by Nolte *et al.* [3] and by Korda *et al.* [12] reported a favorable trend in avoidable mortality for Europe and in other Western countries over the period 1980-1998. Our study not only confirms that a similar trend was present in the Umbria region but also shows that the decrease in avoidable mortality rates continued even in the first decade of the years 2000. The Italian health system is facing, like in most Western countries, difficulties in improving and even maintaining health achievements due to the pending reduction of economic resources available for research, health care and for health prevention campaigns. Today the challenges are no longer just local, national or European. They are no longer

**Figure 4**
Mortality trend from external causes (V01-Y99) by gender, 1994-2009




AADR: age-adjusted mortality rates.

just within the domain of health professionals. They are political and cross-sectoral. They are intimately linked to environment and development. In the future it will be necessary to evaluate health interventions and to improve the relations with the other public sectors that influence population health (*e.g.* economic, environment, education), demonstrating that implementing public health systems is in investment and not a cost.

***Conflict of interest statement***

The Regional Causes of Death Registry is funded by the Regional Health Service Department. There are no potential conflicts of interest or any financial or personal relationships with other people or organizations that could inappropriately bias conduct and findings of this study.

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