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Tobacco attributable morbidity and hospital costs in Piedmont: forecast for the years 2003-2014

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Abstract

Background: Tobacco smoke is the main cause of mortality and morbidity in most industrialized countries. The aim of this study is to forecast the smoke-related morbidity for the residents in Piedmont for the years 2003-2014 and the relative costs for the regional health service, using as an indicator the number of hospital admissions caused by smoke and as an instrument the DRG rates.
Methods: The model uses the risk of hospitalisation among non smokers to predict smoke related morbidity for the period 2003-2014 for both smokers and ex-smokers, by using relative risks (RRs) and smoking prevalence. It should be noted that, because of the 15-year latency between smoke exposure and health outcomes, smoking prevalence of the appropriate time period has been applied to the morbidity data of the following 15 years, thus because of the shift of birth cohorts we are able to make forecasts up until the year 2014.
Basing on these data it is possible estimate, separately for smokers and ex-smokers, the aetiological fraction (PAR%) used to estimate smoking attributable admissions and smoking attributable costs.
The costs attributable to admissions for smoke-related diseases have been estimated using prices set for 2002 as well as prices adjusted for inflation.
Results: A total of 145801 hospitalizations are expected among men and 36959 among females for the period 2003-2014. The economic value of the attributable admissions, at prices adjusted for inflation, increases in the period 2003-2014 with a slowdown in 2014. Data show that in 2014, compared to 2003, a smaller amount of resources, in true value, have been allocated to smoking related admissions (- 11.08%).
Conclusions. The model used meta-analytic RR real prevalence data, considering a fifteen-year latency period between exposure and its effect on health.
Furthermore, an economic estimate is made for each DRG instead of applying medium rates for Major Diagnostic Categories as is frequently seen at a national level.

Key words: smoking, attributable morbidity, hospital costs, forecasts

Introduction

Tobacco smoke is the main cause of mortality and morbidity in most industrialized countries: each year tobacco consumption is responsible for about 3.5 million deaths.

It has been estimated that in the world about 1 billion people smoke and this number is destined to increase so much so that it will reach 1.6 billion smokers by 2025 [1].

As seen in a previous study [2] morbidity is extremely useful not only in determining the economic burden imposed by smoking, but also in order to evaluate the appropriateness of the relationship between supply and demand of hospital services in order to facilitate efficient resource allocation.

Furthermore in the Piedmont region a regional plan against tobacco (PRAT) was carried on starting from 2003, which outlines the relevance of estimating and forecasting the health and economic impact of smoking.

So, after having described the smoke attributable morbidity for Piedmont residents in the years 1997-2002 and the related costs for the regional health service in a previous article [2], the aim now is to estimate the smoking attributable morbidity and related costs for the regional health service until the year 2014, using as the indicator the number of induced admissions and as the instrument the Diagnosis Related Groups (DRG) rates.

Matherial and methods

The following data were essential for the creation of the forecasting model:

1) *sex, age and cause specific base risk of hospitalization: the risk that is not related to smoking and which should not vary over time ($T_{non\ smokers}$)*

This was estimated as follows:

a) Identification of smoke-related diseases, on the basis of data from systematic reviews, [3] as well as the specific metanalytic Relative Risks (RR), stratified for smokers and non-smokers (Table 1).
Though the range of smoke-related diseases in the literature varies [4,5] as well is being quite extensive in some cases [3], we selected only those causes for which there was sound evidence of a relationship with smoking and which represent the most important costs for the Regional Health System.

b) Extraction of the hospital admissions for smoking-related diseases using the classification ICD-IX-CM and for age classes (8 x five-year age classes from 30 to 70 years) from the Hospital Discharge Records for the years 1997-2002, which related to Piedmont residents.

c) Extraction from ISTAT files of the size of the resident population for the years 1997-2002 [6] .
These data were used to estimate sex, age and cause specific hospitalization rates for the whole population for the period 1997-2002 [7] , using the formula (a)

$$T_{population} = n/N \quad (a)$$

where:
n= number of hospitalizations for a specific cause, sex and age class
N= numerosity of given age class in each sex, and then to estimate $T_{non\ smokers}$, using the formula (b):

$$T_{non\ smokers} = T_{population} / [(P_{non\text{-}smokers}) + (P_{ex\text{-}smokers} * RR_{ex\text{-}smokers}) + (P_{smokers} * RR_{smokers})] \quad (b)$$

where:
$T_{population}$ = hospitalization rate for specific smoking related causes in a specific age class of the population
$T_{non\ smokers}$ = hospitalization rate in a specific age class of non smokers
$P_{non\text{-}smokers}$ = non smoker prevalence in a specific age class
$P_{ex\text{-}smokers}$ = ex smoker prevalence in a specific age class
$RR_{ex\text{-}smokers}$ = relative risk for ex smokers in a specific age class
$P_{smokers}$ = smoker prevalence in a specific age class
$RR_{smokers}$ = relative risk for smokers in a specific age class.

Table 1. Metanalytic RR for specific causes (English, 1995-modified)

Cause (ICD-9-CM)	Ex smoker RR (95% CI)	Smoker RR (95% CI)
Oropharyngeal cancer *(141;143-146;148;149)*	1.76 (1.47-2.11)	4.55 (3.97-5.20)
Oesophageal cancer *(150)*	1.79 (1.51-2.13)	4.01 (3.37-4.77)
Stomach cancer *(151)*	1.11 (1.01-1.21)	1.41 (1.29-1.55)
Pancreatic cancer *(157)*	1.15 (1.07-1.24)	1.86 (1.73-2.00)
Laryngeal cancer *(161)*	2.86 (1.87-4.39)	7.48 (4.77-11.7)
Lung cancer *(162)*	M 6.75 (6.16-7.40) F 5.07 (4.66-5.51)	M 13 (12.2.-13.7) F 11.4 (10.5-12.3)
Bladder cancer *(188)*	1.66 (1.57-1.75)	2.72 (2.60-2.85)
Renal pelvic cancer *(189.1)*	1.95 (1.44-2.64)	3.96 (2.93-5.36)
IHD *(410-414)*	Age <65: 1.45 (1.41-1.50) Age 65+: 1.12 (1.07-1.16)	Age <65: 3.06 (3.00-3.13) Age 65+: 1.66 (1.59-1.74)
Stroke *(430-438)*	Age <65: 1.30 (1.12-1.50) Age 65+: 1.15 (1.07-1.24)	Age <65: 3.12 (2.80-3.47) Age 65+: 1.65 (1.52-1.79)
Arteriosclerosis *(440-448))*	1.82 (1.70-1.95)	2.54 (2.42-2.67)
Pneumonia and influence *(480-487)*	1.29 (1.15-1.45)	1.47 (1.33-1.61)
COPD (490-492;496)	6.70 (6.20-7.20)	9.8 (9.2-10.2)
Peptic ulcer *(531-534)*	2.24 (2.05-2.45)	2.07 (1.95-2.20)

2) Smoking prevalence by sex and age class and different level of exposure (smoker, non smoker, ex smoker)

Data for 1987; 1990-91; 1993-1999 [8-9] were extracted from the ISTAT data base.

It should be noted that, because of the 15-year latency between smoke exposure and health outcomes [10], the smoking prevalence of a certain period has been applied to the morbidity data of the following 15 years, thus because of the shift of birth cohorts we are able to make forecasts up until the year 2014.

3) Resident population by sex and age class

Forecasts for the period 2002-2014 were extracted from the ISTAT database [6].

4) Inflation rate

The forecast for the period 2003-2014, equal to a yearly increase of 2% were extracted from records from the European Central Bank (BCE) [11].

5) Estimation of hospitalizations for smoking related causes

Based on these data, we were able to estimate the following for the period 2003-2014 [7]:

- Cause specific hospitalization rate (Table 1) by sex in a specific age class of the population, using a derivation of the formula (b),
- Number of expected hospitalisations (N_{exp}) by specific cause, sex and age, using the formula (c)

  $N_{exp} = T_{population} * N_{population}$ (c)

  where:

  N_{exp} = Number of expected hospitalization by specific smoking related causes, sex and age

  $T_{population}$ = hospitalisation rate for specific smoking related causes in a specific age class of the population

  $N_{population}$ = population size in a specific age class
- Number of hospitalisations attributable to smoking (N_{att}) by specific cause, sex and age, using the formula (d):

  $N_{att} = N_{exp} * PAR\%$ (d)

  where:

  N_{att} = Number of hospitalisations attributable to smoking by specific cause, sex and age

  N_{exp} = Number of expected hospitalisations by specific cause, sex and age

  PAR% = aetiological fraction

  PAR% was estimated separately for smokers and ex smokers, using the formulas (e) and (f)

  $PAR\% = [(T_{smokers} - T_{non\ smokers}) * P_{smokers}] / T_{population}$ (e)

  $PAR\% = [(T_{ex\ smokers} - T_{non\ smokers}) * P_{ex\ smokers}] / T_{population}$ (f)

The hospitalization rate for ex smokers or smokers was obtained by multiplying the specific RR by the hospitalization rate in non smokers.

6) Estimation of hospitalizations for causes not related to smoking (other causes not included in Table 1)

In this case we estimated the average hospitalisation rate (AHR) for the period 2000-2002 and we assumed it to be stable; total number of hospitalisations for other causes, not included in Table1 were estimated by multiplying the sex and age specific rate for the estimated size of the population (Formula g):

$$N_{OTHER\ CAUSES} = \sum_{J=i}^{2} \sum_{w=1}^{8} AHR_{jw} * N_{jw} \quad (g)$$

where:

J = gender

W = age class

7) Estimation of the hospital costs of smoke-related admissions

The costs associated to smoke-related admissions was determined, for each year, using the following formula (h):

$$\sum_{J=1}^{2} \sum_{K=1}^{2} \sum_{w=1}^{8} \sum_{i=1}^{n} [N_{att\ jiwk} * \text{average cost admissions DRG rates } 2002_{jiw}] \quad (h)$$

Where: J stands for male and female gender, K stands for smoker and ex-smoker categories, W represents the age classes (30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69) and I is the specific causes listed in Table 1.

The costs attributable to admissions for smoke-related diseases has been estimated not only in 2002 prices but also for values adjusted for inflation.

8) Estimation of the hospital costs of all causes listed in Table 1 and of other causes

The costs of admissions for all causes listed in Table 1 were calculated, for each year, using the following formula (i):

$$\sum_{J=1}^{2} \sum_{w=1}^{8} \sum_{i=1}^{n} [N_{exp\ jiw} * \text{average cost admissions DRG rates } 2002_{jiw}] \quad (i)$$

The costs of admissions for other causes were determined, for each year, by the following formula (l):

$$\sum_{J=1}^{2} \sum_{w=1}^{8} [N_{\text{OTHER CAUSES } jw} * \text{average cost admissions DRG rates } 2002_{jw}] \quad (l)$$

In order to estimate average costs for admissions all DRG rates were used excepted for the ones which refer to the causes listed in Table 1.

Results

Estimated trend of the number of admissions related to smoking and of the attributable proportion for 2003-2014

Figure 1 shows the trend, stratified by gender, of PAR%.

In the absence of intervention a decrease of PAR% from 7.57% in 2003 to 6.37 % in 2014 is expected among males, while in women a fluctuating trend from 1.40% in 2003 to 1.70% in 2014 is expected.

The variations in PAR% could be partly explained by the fact that in our model we used a latency of 15 years: according to ISTAT data [8-9] the prevalence of male smokers decreased from 28.60% in 1987 to 24.50% in 1999, therefore we purport that in the years to come we will take advantage of the smoking prevalence decrease observed in the '90s. Among women the fluctuating trend of the PAR% probably reflects the fluctuations of smoking prevalence in the '90s, with values around 17%, even if an increasing trend can be observed.

More relevant, in terms of economic burden, is the absolute number of expected hospitalisations. Figure 2 shows the trend, cumulated and stratified by gender, of the absolute number of admissions for smoking related causes. A total of 145801 hospitalisations is expected among men and 36959 among females for the period 2003-2014.

Trend of economic values of smoke-related admissions

The economic value, at prices adjusted for inflation, of the attributable admissions, increases during the period 2003-2014 with a slowdown in 2014 (2003:70538; 2004:70028; 2005:70310; 2006:71176; 2007:71809; 2008:72834; 2009:76677; 2010:76941; 2011:78414; 2012:78264; 2013:78343; 2014:77984 thousand euros), while the costs, at 2002 DRG rates , show a downward trend in the same period (2003:69155; 2014:61489 thousand euros). Data shows that in 2014, compared to 2003, a smaller amount of resources, in true value, will be allocated to smoking related admissions (- 11.08%).

The percentage of burden for the smoke-related costs on the costs sustained for admissions for all causes listed in Table 1(obtained by dividing the value derived from the formula (h) by the value derived from the formula (i)) decreases in 2014 compared to 2003 (2003:43.42%; 2014:40.13%), while 2004 to 2013 shows a fluctuating trend (Figure 3).

The percentage of burden for the smoke-related costs on the costs sustained by the Region for all admissions (obtained by dividing the value derived from the formula (h) by the value derived from the formula (i) plus the value derived from formula (l)) is equal to 4.41% in 2003 and to 3.97% in 2014; from 2004 to 2013 shows a fluctuating trend (Figure 3).

Figure 1. Trend in PAR%, by sex. Piedmont-2003-2014

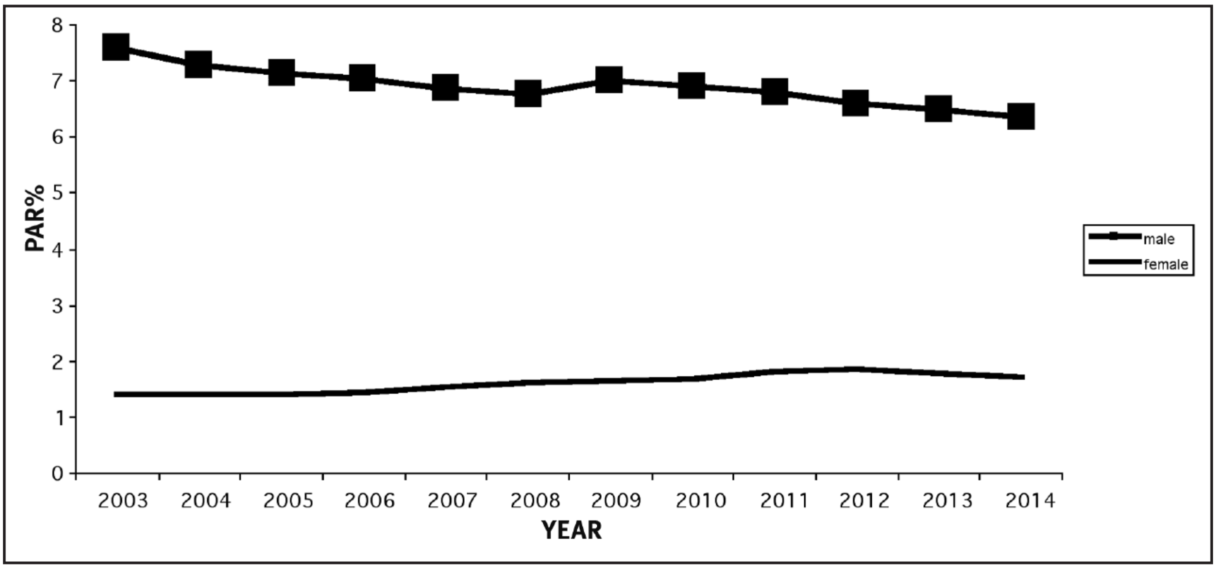
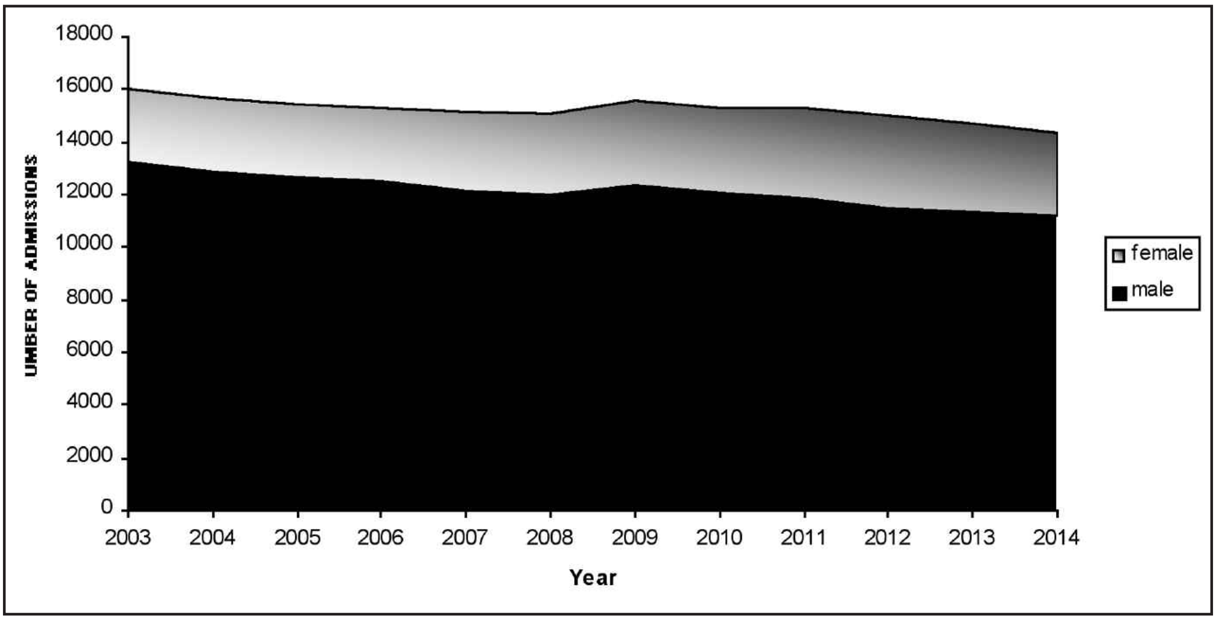


Figure 2. Number of smoking attributable hospitalizations in Piedmont, by sex - 2003-2014



From the analysis of economic data stratified by sex (Figure 4) we can state that the economic value, at prices adjusted for inflation, of the attributable admissions increases for men in 2014 (61396 thousand euros) compared to 2002 (58926 thousand euros). From 2004 to 2013 the hospital costs related to tobacco smoking show a slight fluctuating trend.

Figure 3. Percentage costs of the smoke-related admissions on costs for admissions for all causes listed in table 1 and on costs for all admissions. Piedmont men-women 30-69 years old. Period 2003-2014

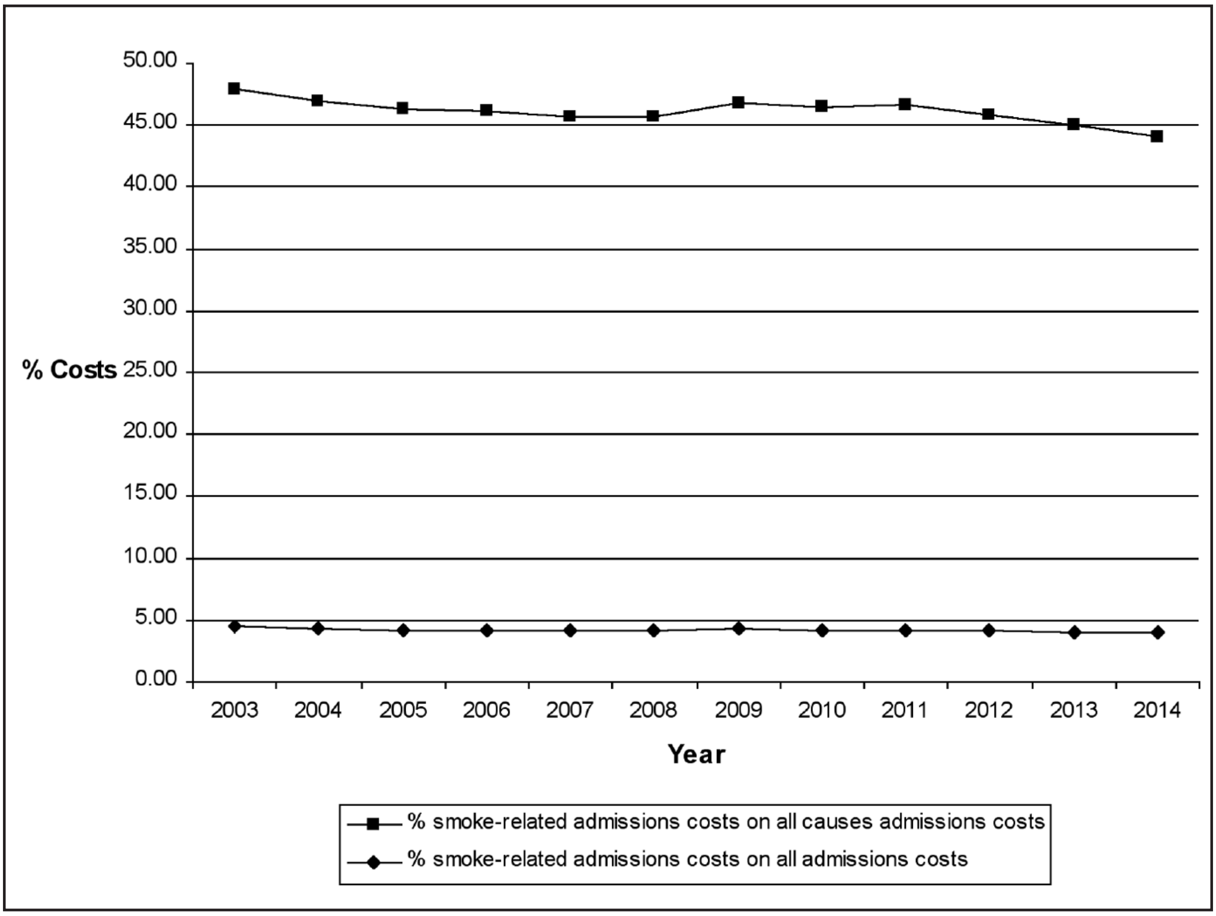
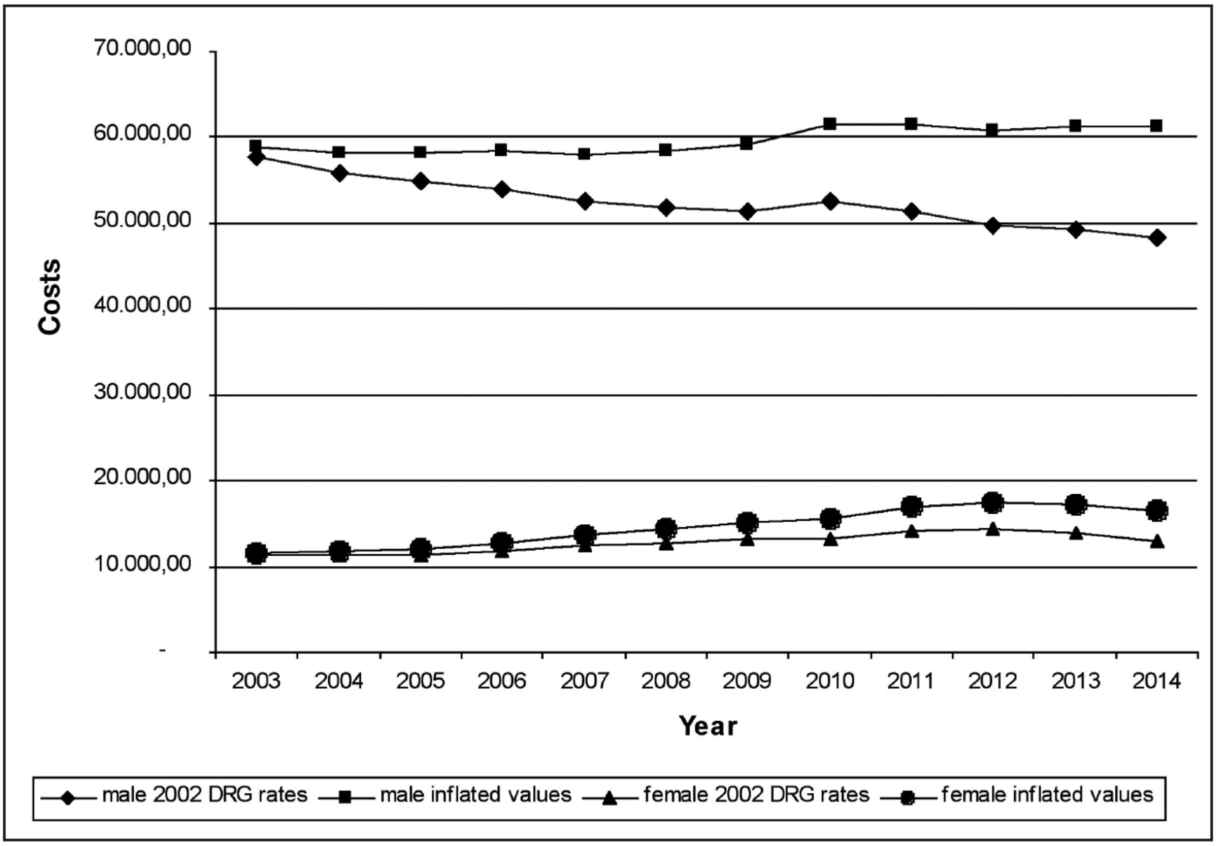


Figure 4. Costs on 2002 DRG rates and inflated values, by gender 30-69 years old. Piedmont 2003-2014 (thousand euros)



While for women the trend increases in the years 2003-2014 with a slowdown in 2013 and 2014.

The admissions costs based on 2002 DRG rates, for men show (with the exception of years 2009 and 2010) a downward trend from 2003-2014, while for women the costs increase during this same period. Data shows that in 2014 a smaller quantity of resources, in true value, will be allocated to smoking related admissions (- 16.20%) for men however a larger amount will need to be allocated for women (14.90%).

Discussion

The aim of this study was to forecast the smoke-related morbidity for the residents in Piedmont for the years 2003-2014 and the relative costs for the regional health service, using as an indicator the number of induced admissions and as an instrument the DRG rates.

The model we used has original characteristics: the forecast used RR derived from the metanalysis of several studies [3] and real prevalence data, and considering a fifteen-year latency period between exposure and effect on health.

As a consequence we created a model more adherent to the natural history of the disease and to the local health problem, providing us with a useful tool for planning purposes.

Furthermore, an economic estimate is made for each DRG instead of applying medium rates for Major Diagnostic Categories as is frequently seen at a national level.

The application of the rate for DRGs, the calculation of which implies the sum of the all productive factors costs used for the single admission, allows us to overcome the limitations of an evaluation restricted to some productive factors and it supplies at the same time a real value of the expense that are really sustained by the local government [12-15].

The economic analysis was carried out from the Regional Health Service point of view and as such we considered the cost values that it sustained. Surely, if the analysis were carried out in the optic of society, we should also consider the indirect costs [16-18].

Data show, among men, a downward trend in PAR% and smoking attributable admissions, except during the period 2009-2010. This fluctuation could be explained by the fact that in 1995 there was a temporary increase in smoking prevalence. Among women data show an upward trend, consistent with smoking prevalence in the '90s.

In the same way, the costs linked to smoke-related admissions decrease in relation to the costs of admissions for the causes identified in

ITALIAN JOURNAL OF PUBLIC HEALTH

Table 1, with a reduction of 7.58% during the twelve–year period. If compared with the costs of all admissions, they show a downward phase with a 10.05% reduction (it goes from 4.41% to 3.97%) which underlines that smoke-related pathologies will be economically lighter than pathologies that are non smoke related, because the number of smoke related admissions decreases more than the number of all hospitalizations.

Finally, the cost related trends could change with the application of a productivity rate.

Aknowledgements

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