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ORIGINAL ARTICLE

# The Italian health surveillance (SiVeAS) prioritization approach to reduce chronic disease risk factors

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**Abstract**

*Objective* Because public health funds are limited, programs need to be prioritized.

*Methods* We used data on 15 risk factors from Italy's public health surveillance to inform prioritization of programs. We ranked risk factors using a score based on the product of six criteria: deaths attributable to risk factors; prevalence of risk factors; risk factor prevalence trend; disparity based on the ratio of risk factor prevalence between low and high education attainment; level of intervention effectiveness; and cost of the intervention.

*Results* We identified seven priorities: physical inactivity; cigarette smoking (current smoking); ever told had hypertension; not having blood pressure screening; ever told had high cholesterol; alcohol (heavy drinking); not eating five fruits and vegetables a day; and not having a fecal occult blood test.

*Conclusions* This prioritization method should be used as a tool for planning and decision making.

**Keywords** Risk factor · Priority · Policy · Planning tool

## Introduction

A prioritization process should be used to help decide how to fund public health programs because of resources constraint (Vilnius and Dandoy 1990). There are approaches to prioritize public health programs that measure burden of disease (Hanlon and Pickett 1979), cost-benefit, or effectiveness ratios (Coffield et al. 2001), whereas other approaches use risk factors directly or indirectly as a basis to estimate disease burden (Weinstein and Stason 1977).

In the past 20 years, with the growing importance of non-transmissible diseases (NTD) and development of NTD risk factors surveillance in the United States (US) and other countries (Mokdad et al. 2003; Baldissera et al. 2011; Moura et al. 2008) planners have begun to use risk factors to set public health priorities (Murray and Lopez 1997).

Nevertheless, there are no published examples of local or regional priority setting that uses the burden methodology; most applications used national or global data (Murray and Lopez 1997). There are several reasons for this gap. First, these methods require complex data and statistical applications (e.g., integral equations and Markov models) not commonly available at public health departments (Murray and Lopez 1997; Muennig et al. 2010). Second, most health surveillance tracks categorical risk

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factors (e.g., smoking yes/no) and preventive/risk factors in primary (e.g., dietary fat,), secondary (e.g., blood cholesterol screening), or tertiary prevention (e.g., hypercholesterolemia) while the methodology requires interval variables and primary risk factors. Third, although public health guides recommend implementation of effective and low-cost interventions (Zaza et al. 2005), there are few explicit, health economic prioritization methods published (Weinstein and Stason 1977). Furthermore, although addressing health disparities is a critical goal of public health programs and routinely tracked (Healthy People 2010), it has not been included in the published prioritization methods.

Finally, most published prioritization approaches rely on a single criterion, such as attributable burden. Yet, policy makers at the local level prefer priority setting and decision making based on many criteria (Baltussen and Niessen 2006). Thus, public health agencies need a prioritization process that uses risk factor surveillance data directly, acceptable policy criteria, and is simple to understand and apply (Rooney and Thompson 2009; Baldissera et al. 2011).

In this paper, we used data from Italian public health surveillance (Baldissera et al. 2011; ISTAT 2003, 2006) and a modification of the risk factor priority model (Simoes et al. 2006) to inform prioritization of chronic disease programs in Italy.

## Methods

### Model

There are 15 risk factors being compared for their priority in public health by applying the risk factor priority model in Italy: cigarette smoking (current smoking); alcohol (heavy drinking); physical inactivity (insufficient active and inactive); not eating five fruits and vegetables a day; overweight and obesity (with categories based on a BMI threshold); ever told had diabetes; ever told had hypertension; ever told had high cholesterol; not having blood pressure screening (prior 2 years); not having cholesterol screening (never); not having a mammography (prior 2 years); not having cervical screening (prior 3 years); not having a rectosigmoidoscopy (prior 5 years); not having a fecal occult blood test (FOBT) (prior 5 years); and not using a front or back seat belt. We used these risk and protective factors because of their known contribution to reducing the burden of disease and for their data availability in the Italian risk factor surveillance system.

The risk factor priority model comprises six criteria: severity (deaths attributable to risk factors); magnitude (prevalence of risk factors); urgency (risk factor prevalence trend); health disparity based on one social determinant factor (risk factor prevalence ratios for those having achieved less than high school vs. with a high school education or more); level of effectiveness of interventions to reduce a risk factor (absolute change in the prevalence of the risk factor attributed to a public health intervention); and cost of this intervention (public health resources only). This prioritization model modulates the severity criterion by comprehensively incorporating the other five criteria in terms of a multiplicative final score.

### Severity criterion

The severity criterion is estimated by the population attributable mortality in 2007. We used prevalence of risk factors from the following: 2007–2009 Risk Behavior Survey PASSI (Baldissera et al. 2011); Italian Health Status and Use of Health Services Survey—ISTAT 2000 and 2005 (ISTAT 2003, 2006); and the relative risk of one or more diseases associated with a risk factor from peer-reviewed publications (Danaei et al. 2009) to generate population attributable fractions (PAF) estimated for age- and gender-specific subgroups (calculation spreadsheet available by author). Prevalence estimates in PASSI are only available for those aged 18- to 69-year old; thus, for calculations of PAF, the prevalence for the age groups 70–79 years and 80 years or older is assumed to be the same as in the age group 65–69 years. For calculations of PAFs of three risk factors with three or more levels, we used the following formula: $PAF = (P_0 + P_1RR_1 + P_2RR_2 + \ldots + P_KRR_K) - 1/(P_0 + P_1RR_1 + P_2 \quad RR_2 + \ldots + P_KRR_K)$ (Centers for Disease Control and Prevention 2006, 2007, 2010). The risk factors were: cigarette smoking that has three exposure levels (never smokers, former smokers, current smokers); alcohol that has four exposure levels (abstainers, 0–39 g, 40–59 g, 60+ g [males]; abstainers, 0–19 g, 20–39 g, 40+ g [females]); and physical inactivity that has four exposure levels (highly active, active, insufficient and inactive).

For dichotomous risk factors, we used the following PAF formula: $PAF = P(RR - 1)/1 + (RR - 1)$ (Levin 1953). Then, PAF were multiplied by death counts estimated from 2007 Italy death records (Geodemo Istat.it. Le Tavole di mortalità 2009) for the same ICD-10 codes to generate population attributable deaths (severity criterion): $AD = PAF \times D$; where $D$ is the total deaths from a specific cause. For each AD value, we have estimated a standardized severity score for all 15 factors using the following formula: $SevScore = AD/SD(AD)$; where SD (AD) is the standard deviation of AD.

### Other criteria

Calculations of magnitude, urgency, and disparity criteria using prevalence estimates from PASSI 2007–2009 are restricted to ages 18–69 years. For this reason, estimates of prevalence for age group 70 years or older are the same as in age group 65–69 years.

The magnitude criterion is the prevalence of the risk factor in PASSI 2007, by age group, and by sex. A magnitude score was calculated for all 15 risk factors using the following formula: MagScore = P/SD ($P$); where ($P$) is the prevalence estimate, and SD ($P$) is the standard deviation of the risk factor prevalence.

The urgency criterion is the percentage change in prevalence of the risk factor between 2 years of PASSI (2007 and 2009) or ISTAT (2000 and 2005), when PASSI data were unavailable (i.e., only for "ever told had diabetes"). The percentage change score formula used for this criterion is as follows: $\Delta = P_{\mathrm{i}} + 1 - P_{\mathrm{i}}/P_{\mathrm{i}}$, where $P$ is the prevalence and "$i$" is the year when $P$ is estimated. We used percentage change to create urgency scores in two ways. First, for each risk factor percentage change value, we have estimated an urgency score using the following formula: UrgScore = (1 + Δ)/SD (1 + Δ); where SD (1 + Δ) is the standard deviation of the percentage change in prevalence, plus 1 during the period. Second, we have estimated an urgency score using the following formula: UrgScore = 1 + (Δ)/SD (Δ).

The disparity criterion is the ratio of the prevalence of the risk factor in 2007 among those who did not reach a high school degree by the prevalence of the risk factor among those who reached a high school graduation or more: Disparity = $P_{<\mathrm{HS}}/P_{>=\mathrm{HS}}$; where $P_{<\mathrm{HS}}$ is the prevalence among those with less than a high school degree, and $P_{>=\mathrm{HS}}$ is the prevalence of risk factor for those with a high school or higher degree. For each prevalence value, a disparity score is created for all 15 risk factors using the following formula: DispScore = Disparity/SD (Disparity); where SD (Disparity) is the standard deviation of the disparity ratio.

The effectiveness criterion is estimated as the absolute change in the prevalence of the risk factor attributed to a public health intervention (net effect). Information on the effectiveness of an intervention was derived from a review of the scientific literature from 1980 to 2007. (see "Appendix" for a list of effectiveness values and sources of information.) A standardized intervention effectiveness score was estimated for each value of population reduction in risk factor (PRRF) across all 15 factors using the following formula: Effective Score = PRRF/SD (PRRF); where SD (PRRF) is the standard deviation of the population reduction in risk factor ratio.

The cost criterion is the per capita cost of a public health intervention for the duration of the intervention trial. Information on cost of interventions for each risk factor and its sources derived from literature are provided in "Appendix". For each value of unit cost, a standardized intervention cost score has been estimated across all 15 factors using the following formula: Cost Score = (1/cost)/SD (1/cost); where SD (1/cost) is the standard deviation of inverse of the cost.

### Weighting

We assigned weights to criteria as multipliers of criteria scores in the following way: (a) a weight of 2 for the scores of severity and cost of intervention criteria because of their importance to Italy's public health and highest relative confidence in their validity; (b) a weight of 1 for the scores of magnitude and disparity criteria to indicate average importance for public health and confidence on their validity; (c) a weight of 0.5 for the scores of urgency (i.e., [0.5 × ((1 + Δ)/(SD (1 + Δ))]) and effectiveness criteria to indicate possible bias as measures of tendency and intervention in effect in Italy; (d) and if the urgency score is negative (i.e., Δ is negative and Δ/SD (Δ) and absolute value is greater than 1 in the formula: [(1 + (Δ)/SD (Δ)], or 1/[(1 + (Δ)/SD (Δ)]), then the value is adjusted by convention to a small, fixed, positive number that takes the values of the inverse of the maximum positive value.

### Risk factor priority final score

For each risk factor, the individual scores of the criteria severity, urgency, magnitude, disparity, effectiveness, and cost were multiplied to generate the final Risk Factor Priority score formula as follows: [(Severity Score) × (Urgency score × Magnitude Score × Disparity Score × Effectiveness Score × Cost Score)].

## Results

Table 1 shows true, unweight and non-standardized indicator values for all six criteria. Table 2 shows indicator values that have been standardized and Table 3 shows indicator values that have been standardized and weighted, thus providing a more accurate view of the relative difference of criteria across risk factors. There were 261,741 deaths attributable to the 15 risk factors, with a significant number of deaths attributed to the top-ranked risk factors: cigarette smoking, ever told had hypertension, physical inactivity, not having blood pressure screening in the past 2-years, alcohol (heavy drinking) and not eating 5 fruits and vegetables a day (Tables 1, 2, 3).

Except for ever told had diabetes with a 5% prevalence, all other 15 risk factors had high prevalence (≥20%), with

**Table 1** Unweight and non-standardized criteria score values of the risk factor priority model, Italy, 2007–2009

| | Severity Deaths attributable to risk factor | Magnitude Risk factor prevalence | Urgency Risk factor prevalence percent change | Disparity Ratio of risk factor prevalence | Effectiveness Percent reduction in risk factor prevalence | Cost Intervention cost per person (US dollars) |
|---|---|---|---|---|---|---|
| Smoking | 86,537 | 0.28 | −0.03 | 1.17 | 0.12 | 4.88 |
| Physical inactivity | 27,348 | 0.73 | −0.01 | 0.77 | 0.35 | 4.31 |
| Overweight and obesity | 9,882 | 0.42 | −0.01 | 1.51 | 0.1 | 41.73 |
| Did not consume five fr/veg a day | 15,911 | 0.91 | 0 | 1 | 0.03 | 10 |
| No PAP in last 3 years | 26 | 0.29 | 0 | 1.45 | 0.18 | 11.44 |
| No mammography | 219 | 0.2 | −0.05 | 1.89 | 0.18 | 550 |
| No fecal occult blood test | 2,702 | 0.92 | −0.01 | 1 | 0.12 | 6.17 |
| Hypercholesterolemia | 5,729 | 0.19 | −0.01 | 1.44 | 0.47 | 10 |
| Hypertension | 55,501 | 0.2 | −0.03 | 1.9 | 0.23 | 10 |
| Diabetes | 1,255 | 0.05 | 0.02 | 2.91 | 0.24 | 10 |
| No seatbelt use | 2,592 | 0.19 | −0.02 | 0.91 | 0.23 | 10 |
| Heavy drinking | 16,415 | 0.12 | −0.09 | 1.59 | 0.08 | 3.97 |
| No rectosigmoidoscopy | 5,565 | 0.97 | 0 | 1 | 0.17 | 81.52 |
| No blood pressure screenin (≤2 years) | 23,444 | 0.17 | −0.01 | 0.83 | 0.32 | 10 |
| No cholesterol screening | 8,615 | 0.21 | −0.05 | 0.83 | 0.08 | 41.73 |

Data sources: Risk factors prevalence from 2007 to 2009 Risk Behavior Survey PASSI and Italian Health Status and Health Services Use Survey, ISTAT 1999–2000, 2005; relative risk from Danaei et al. (2009); Mortality data from the 2009 Italy death records (Geodemo Istat.it. Le Tavole di mortalità 2009)

73% of the populations estimated to be physically inactive and more than 90% not ever having a rectosigmoidoscopy in prior 5 years, not ever having FOBT in prior 5 years, and not eating 5 fruits and vegetables a day; all top-ranked risk factors for magnitude (Tables 1, 2, 3).

Among top-ranked risk factors for urgency, ever told had diabetes experienced a significant increase in prevalence in 5 years (2%), and the prevalence of not eating 5 fruits and vegetables a day, not having cervical screening in prior 3 years and not having a rectosigmoidoscopy in prior 5 years were flat between 2007 and 2009, while all other risk factors had lower priority with decreased prevalence in this period (Tables 1, 2, 3). There was a marked reduction in the prevalence of alcohol (heavy drinking), cigarette smoking, never having cholesterol screening and ever told had hypertension over the same period.

Diabetes presented the highest disparity score with nearly threefold higher prevalence for persons who had less than a high school education compared to a person with a high school education, followed by ever told had hypertension, not having a mammography in prior 2 years with about 90% higher prevalence rate (Tables 1, 2, 3). Alcohol (heavy drinking), overweight and obesity, ever told had high cholesterol and cigarette smoking all presented disparity but at a lower level.

Most community-based interventions had low (10%) to moderate (50%) effectiveness to reduce risk factor prevalence (Tables 1, 2, 3). The cost of implementing an intervention per person reached varied from a low of $4.31 (US dollar) for promoting physical activity to a high of $550 (US dollar) for mammography programs in the US.

We used natural breaks in the scores for the six criteria and the final Risk Factor Priority score to rank order priorities. Table 4 presents the risk factor priority model final ranking of risk in four ways: (a) model 1 includes the severity criterion score only; (b) model 2, consisting of the product of all six unweight and standardized criteria scores; (c) model 3, consisting of the product of five standardized criteria scores weighted and the rescaled urgency score weighted by constrained maximum values (see "Methods" and Tables 2, 3 footnotes); and (d) model 4, consisting of the product of five standardized criteria scores and the rescaled urgency score, all weighted (see "Methods" and Table 2, 3 footnotes).

Compared to model 1, ranking of the top and bottom priority risk factors in models 2, 3 and 4 was mostly

**Table 2** Standardized criteria score values of the risk factor priority model: Italy, 2007–2009

| | Severity Deaths attributable to risk factor | Magnitude Risk factor prevalence | Urgency[a] Risk factor prevalence percent change | Urgency[b] Risk factor prevalence percent change | Disparity Ratio of risk factor prevalence | Effectiveness Percent reduction in risk factor prevalence | Cost Intervention cost per person (US dollars) |
|---|---|---|---|---|---|---|---|
| Smoking | 3.6 | 0.86 | 35.05 | −0.18 | 2.04 | 0.98 | 2.65 |
| Physical inactivity | 1.14 | 2.28 | 35.77 | 0.53 | 1.34 | 2.96 | 3 |
| Overweight and obesity | 0.41 | 1.31 | 35.87 | 0.64 | 2.63 | 0.8 | 0.31 |
| Did not consume five fr/veg a day | 0.66 | 2.82 | 36.41 | 1.18 | 1.75 | 0.27 | 1.29 |
| No PAP in last 3 years | 0 | 0.92 | 36.18 | 0.95 | 2.53 | 1.52 | 1.13 |
| No mammography | 0.01 | 0.64 | 34.52 | −0.71 | 3.31 | 1.54 | 0.02 |
| No fecal occult blood test | 0.11 | 2.87 | 35.98 | 0.75 | 1.76 | 0.97 | 2.1 |
| Hypercholesterolemia | 0.24 | 0.59 | 35.99 | 0.75 | 2.52 | 3.98 | 1.29 |
| Hypertension | 2.31 | 0.63 | 35.11 | −0.12 | 3.33 | 1.9 | 1.29 |
| Diabetes | 0.05 | 0.16 | 36.91 | 1.68 | 5.08 | 1.99 | 1.29 |
| No seatbelt use | 0.11 | 0.58 | 35.58 | 0.34 | 1.59 | 1.9 | 1.29 |
| Heavy drinking | 0.68 | 0.39 | 32.89 | −2.34 | 2.78 | 0.68 | 3.26 |
| No rectosigmoidoscopy | 0.23 | 3.03 | 36.08 | 0.85 | 1.76 | 1.44 | 0.16 |
| No blood pressure screenin (≤2 years) | 0.98 | 0.53 | 35.91 | 0.67 | 1.45 | 2.68 | 1.29 |
| No cholesterol screening | 0.36 | 0.64 | 34.31 | −0.93 | 1.45 | 0.64 | 0.31 |

Data sources: Risk factors prevalence from 2007 to 2009 Risk Behavior Survey PASSI and Italian Health Status and Health Services Use Survey, ISTAT 1999–2000, 2005; relative risk from Danaei et al. (2009); Mortality data from the 2009 Italy death records (Geodemo Istat.it. Le Tavole di mortalità 2009)

Standardized = criteria indicator divided by its standard deviation

[a] Urgency criterion score has been rescaled as: $(1 + \Delta)/\mathrm{SD}(1 + \Delta))$; where $\Delta$ = percentage change and SD = standard deviation

[b] Urgency criterion score has been rescaled as: $(1 + (\Delta)/(\mathrm{SD}\ (\Delta))$; where $\Delta$ = percentage change and SD = standard deviation

similar. However, significant shifts in ranking were noted after standardization and weighting for overweight and obesity that went from 7th to 9th; not having a FOBT that went from 13th to 8th; and hypercholesterolemia that went from 9th to 5th place.

## Discussion

To our knowledge, there were no reported assessments of priorities for public health programs in Italy that used criteria similar to the risk factor priority model. The top six priorities in risk factor reduction for Italy in 2009 on the basis of the severity criterion alone are as follows: cigarette smoking, ever told had hypertension, physical inactivity, not having blood pressure screening, alcohol (heavy drinking), and not eating 5 fruits or vegetables a day. After introduction of the other five priority criteria, hypercholesterolemia and never having had a FOBT join the other six factors among the top eight priorities in the risk factor priority model.

The risk factor priority model modulates the severity criterion (i.e., attributable mortality) by incorporating criteria such as temporal trend of the risk factor, risk factor magnitude, risk factor disparity between groups defined by educational status, level of intervention effectiveness to reduce a risk factor, and the cost of this intervention. In a recent review of priority setting for the health-care field in the developing world (Youngkong et al. 2009), few approaches used quantitative tools or resulted in a rank ordering of interventions as presented in this paper.

Our finding that the top risk factor priorities using this model are mostly influenced by their ranking of the severity criteria should be cautiously interpreted. The severity criterion captures the potential long-term effect of a risk factor on chronic disease, as in the causal relationship between cigarette smoking and lung cancer (i.e., 15–30 years of induction period). Therefore, this measure may over represent the true effect of a risk factor because the factor prevalence and mortality are measured in the present.

The method and data presented in this paper have other limitations. First, the model does not incorporate a political view or the perceptions of stakeholders on priorities as recommended by many (Ryan et al. 2001). Second, our

Table 3 Standardized and weighted criteria score values of the risk factor priority model: Italy, 2007–2009

| | Severity Deaths attributable to risk factor | Magnitude Risk factor prevalence | Urgency[a,b] Risk factor prevalence percent change | Urgency[c,d] Risk factor prevalence percent change | Disparity Ratio of risk factor prevalence | Effectiveness Percent reduction in risk factor prevalence | Cost Intervention cost per person (US dollars) |
|---|---|---|---|---|---|---|---|
| Smoking | 7.21 | 0.86 | 17.53 | 0.6 | 2.04 | 0.49 | 5.3 |
| Physical inactivity | 2.28 | 2.28 | 17.88 | 0.6 | 1.34 | 1.48 | 6 |
| Overweight and obesity | 0.82 | 1.31 | 17.94 | 0.64 | 2.63 | 0.4 | 0.62 |
| Did not consume five fr/veg a day | 1.33 | 2.82 | 18.21 | 1.18 | 1.75 | 0.14 | 2.59 |
| No PAP in last 3 years | 0 | 0.92 | 18.09 | 0.95 | 2.53 | 0.76 | 2.26 |
| No mammography | 0.02 | 0.64 | 17.26 | 0.6 | 3.31 | 0.77 | 0.05 |
| No fecal occult blood test | 0.23 | 2.,87 | 17.99 | 0.75 | 1.76 | 0.49 | 4.19 |
| Hypercholesterolemia | 0.48 | 0.59 | 17.99 | 0.75 | 2.52 | 1.99 | 2.59 |
| Hypertension | 4.62 | 0.63 | 17.56 | 0.6 | 3.33 | 0.95 | 2.59 |
| Diabetes | 0.1 | 0.16 | 18.45 | 1.68 | 5.08 | 0.99 | 2.59 |
| No seatbelt use | 0.22 | 0.58 | 17.79 | 0.6 | 1.59 | 0.95 | 2.59 |
| Heavy drinking | 1.37 | 0.39 | 16.45 | 0.6 | 2.78 | 0.34 | 6.51 |
| No rectosigmoidoscopy | 0.46 | 3.03 | 18.04 | 0.85 | 1.76 | 0.72 | 0.32 |
| No blood pressure screenin ($\leq$2 years) | 1.95 | 0.53 | 17.95 | 0.67 | 1.45 | 1.34 | 2.59 |
| No cholesterol screening | 0.72 | 0.64 | 17.15 | 0.6 | 1.45 | 0.32 | 0.62 |

Data sources: Risk factors prevalence from 2007 to 2009 Risk Behavior Survey PASSI and Italian Health Status and Health Services Use Survey-ISTAT 1999–2000, 2005; relative risk from Danaei et al. (2009); mortality data from the 2009 Italy death records (Geodemo Istat.it. Le Tavole di mortalità 2009)

Standardized = criteria indicator divided by its standard deviation

[a] Urgency criterion score has been rescaled as: $(1 + \Delta)/SD(1 + \Delta))$; where $\Delta$ = percentage change and SD = standard deviation

[b] Weight = 0.5

[c] Urgency criterion score has been rescaled as: $(1 + (\Delta)/(SD\ (\Delta))$; where $\Delta$ = percentage change and SD = standard deviation

[d] Urgency criterion score has been adjusted (weighted) by its maximum or its inverse

literature review included studies regardless of the time allowed for intervention effect and the appropriateness of the implementation. Third, although estimates of PAFs were calculated within gender or age groups, and utilized RR fully adjusted for confounding, confounding may be still present and cause misestimating (Benichou 2001). Fourth, the urgency criterion is based on only 2 years of prevalence data for all but one risk factor; thus, a true risk factor trend effect on the model is likely unknown. Fifth, because effectiveness and cost estimates used in the model are from U.S. public health programs or studies, they likely misestimate effect and cost of a preventive strategy in Italy. A final limitation is that estimated PAF should be used when the risk factor is causally related to the outcome, and there is consensus that the exposure is amenable to intervention (Rockhill et al. 1998). Though the screening practices used in the risk factor priority model are amenable to public health intervention, their unavailability will not necessarily increase people's risk of developing or dying of chronic diseases. However, our approach is easy to adapt and apply by local health departments to set priorities for interventions when resources are limited. Indeed, given the uncertainties and the sensitivity of the risk factor priority model to variations within and across criteria, weighting of criteria and sensitivity analysis is recommended. The weighting of criteria scores did not substantially change the top risk factor priorities.

Our finding of the risk factor priorities for chronic disease prevention in Italy has policy implications. In the WHO European region in 2005, 77% of all Disabiliy-Adjusted-Life-Years (DALYs) and 86% of premature deaths are related to non-communicable diseases, of which approximately 73% are caused by cardiovascular disease, cancer, and diabetes (Singh 2008). In addition, rates of death and disability caused by chronic diseases are predicted to continue growing among people in high-income countries (Suhrcke et al. 2007; Mathers and Loncar 2007).

**Table 4** Ranking of risk factors on the basis of the risk factor priority model calculated in four ways: Italy, 2007–2009

| Ranking | Model 1[a] | Model 2[b] | Model 3[c] | Model 4[d] |
|---|---|---|---|---|
| 1 | Smoking | Physical inactivity | Physical inactivity | Physical inactivity |
| 2 | Hypertension | Smoking | Smoking | Smoking |
| 3 | Physical inactivity | Hypertension | Hypertension | Hypertension |
| 4 | No blood pressure screening $\leq$2 years | No blood pressure screening $\leq$2 years | No blood pressure screening $\leq$2 years | No blood pressure screening $\leq$2 years |
| 5 | Heavy drinking | Hypercholesterolemia | Hypercholesterolemia | Hypercholesterolemia |
| 6 | Did not consume five fr/veg a day | Heavy drinking | Did not consume five fr/veg a day | Heavy drinking |
| 7 | Overweight and obesity | Did not consume 5 fr/veg a day | Heavy drinking | Did not consume five fr/veg a day |
| 8 | No cholesterol screening | No fecal occult blood test | No fecal occult blood test | No fecal occult blood test |
| 9 | Hypercholesterolemia | Overweight and obesity | No rectosigmoidoscopy | Overweight and obesity |
| 10 | No rectosigmoidoscopy | No rectosigmoidoscopy | Overweight and obesity | No rectosigmoidoscopy |
| 11 | No fecal occult blood test | No seatbelt use | Diabetes | No seatbelt use |
| 12 | No seatbelt use | Diabetes | No seatbelt use | Diabetes |
| 13 | Diabetes | No cholesterol screening | No cholesterol screening | No cholesterol screening |
| 14 | No mammography | No PAP | No PAP | No PAP |
| 15 | No PAP | No mammography | No mammography | No mammography |

[a] Model 1: includes only the severity criterion

[b] Model 2: product of all six criteria that have been standardized

[c] Model 3: product of five criteria that have been standardized and weighted, multiplied by the urgency score weighted as: Max of $[(1 + (\Delta)/SD(\Delta)]$, or $1/[(1 + (\Delta)/SD\ (\Delta)]$; where $\Delta$ = percentage change and SD = standard deviation

[d] Model 4: product of five criteria that have been standardized and weighted, multiplied by the urgency score weighted as: $[0.5 \times ((1 + \Delta)/(SD\ (1 + \Delta))]$; where $\Delta$ = percentage change and SD = standard deviation

Although tobacco smoking was second priority in the Risk Factor Prioritization model, it is trending down in Italy. In Europe over the past 30 years, the proportion of smokers has dropped to 15%. Conversely, tobacco use is rising in eastern Europe and still remains the leading avoidable cause of death in industrialised nations (Novotny 2008; World Health Organization 2002).

Both hypertension and not having had a blood pressure screening ranked among top priorities in the Risk Factor Prioritization model. It has been reported that men and women in western Europe had the highest systolic blood pressure (SBP) among high-income regions (Danaei et al. 2001). Female SBP decreased in western Europe and Australasia, whereas male SBP fell most in high-income North America, followed by Australasia and western Europe where it decreased by more than 2.0 mm Hg per decade (posterior probabilities >0.98).

Alcohol as measured by heavy drinking causes chronic illnesses, such as alcohol dependence, vascular disease (e.g., hypertension), hepatic cirrhosis, and various cancers and contributes to accidental deaths. The global loss of DALYs attributed to alcohol is 4.7%, whereas the share for eastern Europe is significantly higher at 10.7% (Jamison 2006; Novotny 2008).

Obesity did not rank high in our models. Though almost a third of all people living in Europe are overweight (James et al. 2004; Novotny 2008), a WHO study found that Italy was the only high-income European country in which female BMI decreased from 1980 to 2008, and Italy and Switzerland had one of the smallest increases in male BMI (Finucane et al. 2011).

Hypercholesterolemia ranked 5th among priorities in the adjusted Risk Factor Prioritization models (standardized or weighted). Despite a downward trend of total cholesterol in the high-income regions of Australasia, North America, and western, central, and eastern Europe, serum total cholesterol in 2008 was the highest in the high-income regions of Australasia, North America, and western Europe (Farzadfar et al. 2011).

Despite its low-final ranking in priority, our finding of an upward trend in diabetes in Italy is supported by published reports that suggest that deaths directly attributable to diabetes are predicted to rise approximately 30% in Europe from 2005 to 2030 (World Health Organization 2006).

Our finding of educational disparities in the prevalence of the risk factor is partially supported by other reports. In a study to evaluate inequity in the occurrence of chronic diseases by education status in Europe, researchers identified a higher prevalence of heart disease, stroke, diabetes, some forms of cancer, and hypertension among the lower education group (Dalstra et al. 2005). Another study reported persistent health status disparity by region in Italy (France et al. 2005).

Policy makers can use the risk factor priority model to address different concerns, as exemplified by alcohol in Italy. If the concern is alcohol severity as expressed by attributable mortality, then it ranked moderate-high (i.e., 6th–7th). If there is also interest in the effectiveness and the low cost of public health strategies to reduce alcohol, then it would rank higher as the 4th priority (data not in tables). On the other hand, if only the magnitude of alcohol today (prevalence) and its urgency (i.e., prevalence trend) are a concern then it would rank very low compared to other risk factors. The magnitude and urgency criteria combined provide planners with a look at the future potential of a risk factor severity, thus allowing for addressing it at the present time. A risk factor severity will increase over time if its magnitude and urgency are high, and cost-effective interventions that reduce it are not available or used.

The risk factors priority model is easy to apply since it uses commonly known epidemiologic measures (i.e., prevalence, number of deaths, relative risk, and PAF) and indicators (e.g., prevalence trend). It is also flexible to include other criteria (e.g., DALYs) and risk/preventive factors (e.g., social determinants of health); as well as to focus on a sub-population (e.g., ranking of NTD risk factor in a minority population). Moreover, the use of multiple priority criteria will increase its acceptability. Previous studies on prioritization showed that stakeholders appreciated the flexibility of choosing critical indicators (Baltussen et al. 2006; Phillips et al. 2010). Our methodology will allow cross country comparison based on readily available risk factors surveillance (Coffield et al. 2001).

Public health professionals in Italy could use our model in order to set better priorities or review as to how their activities compared with our findings. Moreover, they could improve the prioritization by collecting and using better data for risk factors and relative risk, as well as applying other methods for estimation of the severity criterion (Bruzzi et al. 1985; Rückinger et al. 2009). Indeed our study should be used to guide health intervention and gather support for action. Finally, the risk factor priority model is a planning tool that should be used together with other approaches in a participatory process of planning (Simoes et al. 2006).

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**Conflict of interest** All co-authors have no conflict of interest associated with any part of the study.

**Ethical standard** This study complies with the current laws of the country in which it was performed.

## Appendix

See Table 5.

**Table 5** Review of effectiveness and cost of public health interventions in the US: 1981–2009

| Risk factor | Reference | Study design | Outcome measure | Intervention effect | Cost/person (community-based) |
|---|---|---|---|---|---|
| Smoking | Hopkins et al. 2001 | Systematic review (Community Guide)<br>Mass media campaigns combined with other interventions | Reduced population tobacco consumption measured as statewide sales of cigarettes (three studies) | Relative change<br>Median −12.8%<br>CI −9.8 to −17.5 | $4.88<br>($3.99 to $6.75)<br>CDC Tobacco Control report, 2007 |
| | | | Reduce tobacco use prevalence (five studies with concurrent comparison populations) | Absolute change Median −3.4%<br>CI −7 to 0.2 | |
| | Abramson et al. 1981 | Community-focused program (CHAD) to control cardiovascular risk factors in Israel | Prevalence of cigarette smoking among men decreased | Absolute change<br>−23%<br>**−11.6%**<br>**CI −23 to 0.2** | |
| Physical inactivity | Kahn et al. 2002 | Systematic review (Community Guide)<br>Informational approaches—community-wide campaigns (highly visible, broad-based, multiple intervention approaches) | Positive change in the % of people being active (five studies) | Relative change 4.2%<br>Range: −2.9 to 9.4% | $4.31<br>Reger-Nash et al. 2006<br>($3.00 to $15.00)<br>Trust for America's Health (2008) |
| | Reger-Nash et al. 2006 | Quasi-experiment, used to determine whether the results of a previous PA social marketing campaign could be replicated in another community | Prevalence of positive change in the % of participants who changed from non-active to active walker | Relative change<br>5% | |
| | Koffman et al. 2001 | Prospective, non-randomized, 12-week educational intervention for women | Percent of women who reported moderate activity levels, 32% at baseline to 67% at program's end | Absolute change<br>35%<br>**35%** | |
| No seat belt use | Escobedo et al. 1992 | Assessed rates and trends in safety belt use by presence and type of safety belt law using data from states participating in the 84-89 BRFSS | Net change in seat belt use for states without seat belt law compared to states with primary and secondary seat belt law | Absolute change<br>Primary 30%<br>Secondary 15% | $10.000<br>($3.00 to $15.00)<br>Trust for America's Health 2008 |
| | Dinh-Zarr et al. 2001 | Systematic review (Community Guide)<br>Summary of effectiveness of safety belt laws on self-reported safety belt use (four studies) | Self-reported seat belt use<br>(four studies) | Relative change<br>16% CI 13 to 19<br>**22.5%**<br>**CI 15 to 30%** | |
| Less than five fruits/vegetables per day | Veerman et al. 2006 | Review and epidemiological modeling (intervention effects on consumption were obtained from an earlier study—pre-post, no comparison group) | Increase in fruit and vegetable consumption | Relative change<br>Fruit: 15%<br>Veg: 13.2% | $10.000<br>($3.00 to $15.00)<br>Trust for America's Health 2008 |
| | Potter et al. 2000 | 5 A Day Program Evaluation (national media program to promote eating five or more servings of fruit/vegetables per day) | Overall increase in fruit/veg consumption | Absolute change<br>3.2%<br>Relative change<br>14.9%<br>**3.2%** | |

**Table 5** continued

| Risk factor | Reference | Study design | Outcome measure | Intervention effect | Cost/person (community-based) |
|---|---|---|---|---|---|
| No FOBT | Baron et al. 2008 | Systematic review (Community Guide)<br>Settings: HMOs in the US, clinics in Canada and Israel | Increase in proportion of FOBT screening<br>(eight studies) | Absolute change<br>11.5% CI 8.9 to 20.3 | $6.17<br>($3.00 to $15.00)<br>Trust for America's Health 2008<br>Baron et al. 2008 (clinical) |
| | Vinker et al. 2002 | Prospective intervention—role of family physicians in increasing FOBT screening | Increase in proportion of FOBT screening | Relative change<br>6.95%<br>**11.5%**<br>**CI 8.9 to 20.3** | |
| No Pap | Yabroff et al. 2003<br>Denberg et al. 2006 | Systematic review<br>(1) sociologic: lay health worker model for Vietnamese American women<br>(2) system change: integrating a nurse practitioner and offering same day screening | Increase in proportion of pap screening | Absolute change<br>18% CI 7.6 to 28.4<br>Absolute change<br>32.7% CI 20.5 to 44.9<br>Relative change<br>38.5%<br>Absolute change<br>7%<br>**18% CI 7.6 to 44.9** | ($3.00 to $15.00)<br>Trust for America's Health 2008<br>$11.44<br>Lantz et al. 1996 (clinical) |
| No mammogram | Yabroff et al. 2001<br>Denberg et al. 2006 | Systematic review<br>Interventions that combined behavioral and theory-based educational strategies with usual care controls, and sociologic interventions | Increase in mammography screening | Absolute change<br>27.3% CI 14.7 to 40.0<br>Absolute change<br>9.1% CI 1.7 to 13.3<br>Absolute change<br>12%<br>**18.2%**<br>**CI 1.7 to 40.0** | ($3.00 to $15.00)<br>Trust for America's Health 2008<br>$11.44<br>Lantz et al. 1996 (clinical) ($81.52)<br>Mandelblatt et al. 2004 (public health)<br>($550)<br>Ekwueme et al. 2008 (public health) |
| No clinical breast exam<br>(overall screening for breast cancer is used as a proxy for clinical breast exams) | Sin and St Leger 1999<br>Williams and Vessey 1989<br>King et al. 1994<br>Stead et al. 1998<br>Turner et al. 1994<br>Atri et al. 1997 | Systematic review<br>Fixed appts on invitation letter<br>–Unpublished data<br>–Reminder letter with fixed appt<br>–Reminder letter with GP endorsement<br>–Receptionist contact by phone or letter | Increase in overall breast exam | Absolute change<br>10% CI 2.9 to 18.4<br>16% CI 11.7 to 21.4<br>11% CI 7.3 to 13.7<br>11% CI 5.0 to 17.9<br>5% CI 3.2 to 7.4<br>**11%**<br>**CI 2.9 to 21.4** | ($3.00 to $15.00)<br>Trust for America's Health 2008<br>$11.44<br>Lantz et al. 1996 (clinical) |

**Table 5** continued

| Risk factor | Reference | Study design | Outcome measure | Intervention effect | Cost/person (community-based) |
|---|---|---|---|---|---|
| No blood pressure screening (never had blood pressure checked) | Aubin et al. 1994 | Retrospective quasi-experimental study<br>Secondary prevention program (education and incentives) to improve hypertension screening in a family practice setting | Improve hypertension screening | Absolute change<br>**31.7%** | $10.00<br>($3.00 to $15.00)<br>Trust for America's Health 2008 |
| Hypertension<br>sbp and dbp<br>(ever been told blood pressure was high) | REACH 2006 | Unpublished data (MI example)<br>we received additional data from the REACH Detroit Partnership<br>$63.3 - 49.2 = 14.1\%$ | Decrease d prevalence of high blood pressure | Absolute change<br>−14.1% | $10.00<br>($3.00 to $15.00)<br>Trust for America's Health 2008 |
| | REACH 2008 | Unpublished data (MA example)<br>REACH Latino Health Project—culturally tailored intervention to reduce diabetes burden | Improvement in<br>sbp below 130 mm Hg and<br>dbp below 80 mm Hg<br>over 3 years | Absolute change<br>sbp: 17.5%<br>dbp: 14.4% | |
| | Abramson et al. 1981 | Community-focused program (CHAD) to control cardiovascular risk factors in Israel (1970 to 1975) | Decreased prevalence of hypertension | Absolute change<br>−31% | |
| | Gofin et al. 1986 | Follow-up: community-focused program (CHAD) to control cardiovascular risk factors in Israel (1976 to 1981) | Decreased prevalence of hypertension | Relative change<br>−3.4%<br>**−22.5%**<br>**CI −31% to −14.1%** | |
| Never had cholesterol screening | Brownson et al. 1996 | Quasi-experimental | Increase in prevalence of having cholesterol checked in past 2 years | Absolute change<br>4.5%, $p = 0.04$ | $41.73<br>$105,000 annually divided by # participants, 2,516 = 41.73<br>Brownson et al. 1996 |
| | REACH 2006 | Unpublished data (GA example) | Increase in prevalence of having cholesterol checked in past 2 years | Absolute change<br>10.6% CI 9.1 to 11.9<br>**7.6%**<br>**CI 4.5% to 10.6%** | |
| Hypercholesterolemia (ever been told cholesterol was high) | Abramson et al. 1981 | Community-focused program (CHAD) to control cardiovascular risk factors in Israel (1970 to 1975) | Reduction in prevalence of hypercholesterolemia | Absolute change<br>−31% | $10.00<br>($3.00 to $15.00)<br>Trust for America's Health 2008 |
| | Emmelin et al. 2007 | 10-year follow-up of a Swedish community intervention program | 63% of participants with a high level at baseline had low levels at follow-up | Absolute change<br>−63% | |
| | MMWR<br>Nov 24, 2006 | Community-based intervention to improve self-care, access to care, and quality of care for residents with diabetes (pre-post) | Reduction in proportion not meeting recommended total cholesterol levels | Absolute change<br>−31.4%<br>**−47%**<br>**CI −63% to −31%** | |

**Table 5** continued

| Risk factor | Reference | Study design | Outcome measure | Intervention effect | Cost/person (community-based) |
|---|---|---|---|---|---|
| Obesity | Brownson et al. 1996 | Quasi-experimental | Stemmed increase in prevalence of overweight | Absolute change<br>−5.9%, $p = 0.07$ | $41.73<br>$105,000 annually divided by # participants, 2,516 = 41.73<br>Brownson et al. 1996 |
| | Abramson et al. 1981 | Community-focused program (CHAD) to control cardiovascular risk factors in Israel (1970 to 1975) | Reduction in prevalence of overweight | Absolute change<br>−13%<br>**−9.5%**<br>**CI −13% to−5.9%** | |
| Diabetes mellitus (glucose or HbA1c) | MMWR<br>Nov 24, 2006 | Community-based intervention to improve self-care, access to care, and quality of care for residents with diabetes (pre-post). Values are based on self-reported diagnosed diabetes. | Reduced proportion of black adults not meeting recommended HbA1c levels | Absolute change<br>**−23.5%** | $10.00<br>($3.00 to $15.00)<br>Trust for America's Health 2008 |
| High dietary fat intake | Koffman et al. 2001 | Prospective, non-randomized, 12-week educational intervention for women | Participants limiting excess calories or fat increased from 72 to 91% | Absolute change **19%**, $p = 0.001$ | $10.00<br>($3.00 to $15.00)<br>Trust for America's Health 2008 |
| Alcohol intake | Shults et al. 2001 | Reviews of evidence regarding interventions to reduce alcohol-impaired driving | Alcohol-related motor vehicle fatalities | Median percent change (absolute measure) = **−7%**<br>(interquartile range, −15% to −4% | $3.97 per person |
| Use and intake | Larimer et al. 2007 | Motivational/feedback approaches | Peak blood alcohol content and frequency of use in the past month from the QFP, total drinks per week from the DDQ, and frequency of drinking in the past year from the Core Institute's Campus Assessment of Alcohol and Other Drug Norms survey | At baseline, 36% of the control group and 35% of the intervention group had reported heavy episodic drinking. At follow-up, 40% of the control group drank heavily, compared with 33% in the intervention group **Net effect = 6% (absolute effect)** | |
| | Chisholm et al. 2004 | Reducing the Global Burden of Hazardous Alcohol Use:<br>A Comparative Cost-Effectiveness Analysis* | Reduction in heavy drinking per day | Reduce alcohol use by approx. **11.1%** (7.7–14.4) in the Americas and **10%** (7.0–12.9) in Europe | |
| | Whitlock et al. 2004 | The U.S. Preventive Services Task Force (USPSTF) recommends screening and behavioral counseling interventions to reduce alcohol misuse | Reduce alcohol use in primary health care patients | Adults: pooled absolute risk reduction ranged from 7% to 14% (11.5). Adolescent: participants in the intervention group were significantly less likely to intend to drink than participants in the control group (5.5% vs 19.2%), were less likely to have reported drinking in the prior 30 days (3.6% vs 17.3%), and were less likely to have consumed 5 => drinks in a row during the prior 30 days (0.0% vs 9.6%) | |

**Table 5** continued

| Risk factor | Reference | Study design | Outcome measure | Intervention effect | Cost/person (community-based) |
|---|---|---|---|---|---|
| Recto sigmoidoscopy and colonoscopy | Myers et al. 2004 | RCT | Proportion of CDE in FU | Absolute difference = 17% | Cost estimate is that for breast cancer given involvement of specialist and high-tech diagnostic equipments: |
| | Dietrich et al. 2006 | RCT | Proportion who had colorectal screening | Absolute difference = 11.7% | |
| | Denberg et al. 2006 | RCT | Screening colonoscopy (flex sigm, colonosc, FOBT) | Absolute Difference = 13% | ($81.52) Mandelblatt et al. 2004 (public health) |
| | Sequist et al. 2009 | RCT | Colorectal screening (flex sigm, colonosc, FOBT) | Absolute Difference = 6% (3.7–10.1) | ($550) Ekwueme et al. 2008 (public health) |

All final intervention effect values are absolute change and highlighted in bold

When relative change values were available, the value is presented but not used as the intervention effect

When several intervention effect values were available, the average of all absolute effects was used as the intervention effect, and the highest and lowest absolute effects were used as the intervention effects' range for each risk factor

All cost estimates presented are community-based except where noted as public health or clinical

Trust for America's Health (TFAH) conducted a comprehensive literature review of community-based, public health interventions. Of the studies that included cost data, most were estimated in the range of $3–$8 per person. TFAH and Prevention Institute consulted a set of experts who agreed that $10 per person is a conservative estimate for the costs of community-based programs. We use this value for all risk factors except those for which cost data are available

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