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The combined effect on survival of four main behavioural risk factors for non-communicable diseases

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ABSTRACT

Objective. To quantify and illustrate the combined effects of WHO's four behavioural risk factors for non-communicable diseases (NCDs) on mortality.

Methods. Participants ($n = 16{,}721$) were part of two Swiss population studies conducted between 1977 and 1993. Smoking status, alcohol consumption, physical activity and diet were assessed at baseline. With record linkage in 2008, up to 31 years of follow-up with 3,533 deaths could be recorded. Mortality was assessed with Cox proportional hazard models for each risk factor and their combinations. Ten-year survival probabilities for 65- and 75-year-olds were estimated with Weibull regression models.

Results. Hazard ratios for the combination of all four risk factors compared to none were 2.41 (1.99–2.93) in men and 2.46 (1.88–3.22) in women. For 65-year-olds, the probability of surviving the next 10 years was 86% for men with no risk factors and 67% for men with four. In women, the respective numbers were 90% and 77%. In 75-year-olds, probabilities were 67% and 35% in men, and 74% and 47% in women.

Conclusions. The combined impact of four behavioural NCD risk factors on survival probability was comparable in size to a 10-year age difference and bigger than the gender effect.

Introduction

Non-communicable diseases (NCDs) have become a major concern in health care and a priority of global health policy (United Nations, 2011). In its current Action Plan for the Global Strategy for the Prevention and Control of Non-Communicable Diseases, the World Health Organization (WHO) has identified four main groups of NCDs (cardiovascular diseases [CVD], cancers, diabetes and chronic respiratory diseases) and four main behavioural risk factors (tobacco use, unhealthy diet, physical inactivity and harmful use of alcohol) (World Health Organization, 2009). The Global Burden of Disease Study 2010 has quantified the impact of those four and other risk factors on global health as population attributable fractions (Lim et al., 2012; Murray et al., 2012). For Western Europe, the eight risk factors with the highest shares on attributable burden of disease were, in descending order, tobacco smoking, high blood pressure, high body mass index (BMI), alcohol use, physical inactivity, high fasting plasma glucose, diet low in fruits and high total cholesterol (Lim et al., 2012). Thus, the top eight of all risk factors for NCDs include four modifiable lifestyle factors and four biological parameters that are associated with at least some of these four behaviours.

An accumulation of clinical risk factors increases morbidity and mortality; particularly for CVD, risk score charts and guidelines for diagnostic and therapeutic procedures in clinical decision making or for risk prediction have been developed based on combinations of clinical parameters (Cooney et al., 2009). However, not only clinical parameters but also unhealthy behaviours are often clustered (Heroux et al., 2012), and it has been shown that mortality increases with an accumulation of unfavourable lifestyle factors including measures of body fatness (Behrens et al., 2013; Carlsson et al., 2012; Dobson et al., 2012; Loef and Walach, 2012). Since behavioural counselling in primary care is an important element of both prevention and therapy, a comprehensive system illustrating directly the effect of behavioural factors could be of particular value for health professionals. Such an illustration could also become an important communication tool for health policy. To our knowledge, risk charts based on the four main behavioural risk factors for NCDs have not been developed so far.

This study therefore aimed at quantifying and illustrating the combined effects of the WHO's four behavioural risk factors for NCDs on total, CVD and cancer mortality, using observational and recent population specific routine data from Switzerland. For this purpose, data from two Swiss population studies were linked to the Swiss National Cohort (SNC), a record linkage project of data from census, death and migration registers.

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Methods

Study populations and record linkage

The sample population, aged 16–90 years at baseline, consisted of participants of two studies on cardiovascular health in Switzerland: the National Research Programme 1A (NRP 1A) (Gutzwiller et al., 1985) and the Swiss Monitoring of trends and determinants in Cardiovascular disease (MONICA) study (Bothig, 1989). The NRP 1A was conducted from 1977 to 1979 in five towns situated in the three main language regions of Switzerland (Aarau, Lugano, Nyon, Solothurn and Vevey) (Bopp et al., 2012). Measurements included a health examination (body weight and height, blood pressure, blood lipids and other biological parameters) and a questionnaire (socio-demographic variables, smoking, alcohol consumption, physical activity and general eating patterns, dietary intake on the day preceding the examination and eating behavior). The Swiss MONICA study included the French- and Italian-speaking but not the German-speaking part of Switzerland, and it was conducted in three waves in 1984–1986, 1988–1989 and 1992–1993 (Wietlisbach, 1987; Wietlisbach et al., 1997). Again, measurements included a health examination and a self-administered questionnaire. We used only variables that were identical or quasi identical in both studies.

In neither of these two studies a mortality follow-up was planned. In order to obtain survival information, data from the SNC, which includes also information on cause of death, were linked to NRP 1A and MONICA participant records in 2008. Details on linkage procedure and success were reported elsewhere (Bopp et al., 2009, 2010, 2012). Briefly, 8008 out of 8539 eligible participants of NRP 1A (93.8%) (Bopp et al., 2012), and 9853 out of 10,160 eligible MONICA participants (97.0%) could be linked with the SNC (Bopp et al., 2010).

For the present analyses, the NRP 1A and MONICA data sets with linked mortality data were then combined. After deleting individuals with missing covariate information ($n = 1140$), data of 16,721 participants remained for analysis, with a total of 357,045 person-years of follow-up and 3,533 deaths. The analyses for this paper were conducted in 2013.

Measurements

All-cause mortality and cause-specific mortality were used as outcome variables. In Switzerland, causes of death were defined according to the 8th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-8) until 1994, and afterwards based on ICD-10. CVD deaths were defined as ICD-8 codes 410–438 and ICD-10 codes I00-I99. Cancer mortality corresponds to ICD-8 codes 140–239 and ICD-10 codes C00-C99 and D00-D48.

The health behaviours included as covariates (see electronic Supplementary material file 1 for questionnaires) in the models were smoking status (current smoker [regular or occasional]; current non-smoker [never or former smoker]), alcohol consumption on the previous day (no; moderate [MONICA: drinking either wine or beer or cider; NRP1A: women drinking less than 20 g/d, men drinking less than 40 g/d]; high [MONICA: drinking spirits or more than one sort of alcohol on the previous day; NRP1A: women drinking more than 20 g/d, men drinking more than 40 g/d]), leisure-time physical activity (LTPA: (low [light physical activity, mostly sedentary]; high [frequent walking or cycling; other frequent activities such as gardening; or regular vigorous physical activity]), and fruit intake on the previous day (no; yes). As an indicator for a healthy diet, we chose fruit intake because of its ranking in the Global Burden of Disease project (Lim et al., 2012). In addition, the following covariates were included: sex, age (years), education (according to the International Standard Classification of Education ISCED: mandatory school [ISCED 0-2], vocational education [ISCED 3], higher vocational education [ISCED 4], university [ISCED 5-6]), marital status (single, married, widowed, divorced/separated), survey (NRP1A, MONICA waves 1–3) and nationality (Swiss, non-Swiss).

Ethical approval

Approval (No. 13/06) for record linkage and the analyses of the resulting data base was obtained from the Ethics Committee of the Canton of Zurich. Written informed consent had been obtained from participants in MONICA (Bothig, 1989), but this procedure was not customary at the time the NRP 1A was conducted.

Statistical analyses

For descriptive analyses, means and standard deviations of the continuous variables and frequencies and proportions of categorical variables were calculated. Hazard ratios describing relations between independent variables and total, CVD and cancer mortality were estimated with Cox proportional hazards models for both sexes separately and combined. All models include the four behavioural factors as well as sex (where appropriate), age, indicators for socio-economic status and survey. The proportional hazards assumption was tested and was sufficiently fulfilled for eight of the nine models presented, the only exception being the model for total mortality in both sexes combined.

Time to event or censoring was defined as time difference between study entry (date of baseline interview) and date of death, or the possible censoring dates of emigration, or end of the study (December 31, 2008), respectively. Model selection was performed based on Akaike's information criterion (AIC) and the Bayesian information criterion (BIC).

In analogy to the SCORE project (Conroy et al., 2003), we then calculated the 10-year probability of survival at ages 65 and 75 years for different combinations of risk factors. For the calculation of such absolute risks, an estimation of the baseline hazard is needed. This cannot be obtained using a Cox proportional hazards model; therefore, a Weibull regression model was used (Faeh et al., 2013). The included covariates were the same as in the Cox proportional hazards models.

We chose $\alpha = 0.05$ as level of significance. The calculations were done with STATA 12.1 (StataCorp LP, College Station, Texas, 2011) and R 2.15.2 (R Foundation for Statistical Computing).

Results

Characteristics of participants

Characteristics of participants at study entry (baseline) are shown in Table 1. Mean age was 45.1 years (SD = 13.5), and the proportion of women was 51.4%.

Risk behaviours and mortality

Cox proportional hazards models were calculated and the hazard ratios (HR) for mortality derived from the multivariate analysis are given in Table 2. In both sexes combined, total mortality was increased

Table 1
Baseline characteristics of participants (MONICA and NRP 1A, Switzerland, 1977-2008).

		Men	Women
N		8132	8589
Mean age in years (SD)		44.9 (13.1)	45.2 (13.8)
Person-years		167,508	189,537
Number of deaths	All causes	1967	1566
	CVD	666	539
	Cancer	705	550
	Other causes	596	477
Educational level	Mandatory (%)	27.5	40.7
	Vocational (%)	50.2	45.4
	Higher vocational (%)	13.2	10.9
	University (%)	9.1	3.1
Marital status	Single (%)	16.2	15.9
	Married (%)	77.8	70.6
	Widowed (%)	1.2	7.1
	Divorced/separated (%)	4.8	6.4
Nationality	Swiss (%)	78.8	84.3
	Non-Swiss (%)	21.2	15.7
Current smoking status	Non-smoker (%)	60.1	73.8
	Smoker (%)	39.9	26.2
Alcohol consumption yesterday	No (%)	29.6	61.9
	Moderate (%)	49.3	32.2
	High (%)	21.1	5.9
Leisure time physical activity	High (%)	72.6	66.9
	Low (%)	27.4	33.9
Fruit consumption yesterday	Yes (%)	65.2	79.4
	No (%)	34.8	20.6

CVD = cardiovascular disease; SD = standard deviation.