The potential impact of a social redistribution of specific risk factors on socioeconomic inequalities in mortality

R. Hoffmann, T.A. Eikemo, I. Kulhánová, M. C. Kulik, M. Toch, G. Menvielle, J.P. Mackenbach and the EURO-GBD-SE consortium

Abstract
Evidence on the contribution of risk factors to health inequality is scarce. We quantify the impact of modifying risk factor distributions on educational mortality differences using the Population Attributable Fraction. This is done for scenarios in which the social distribution of risk factors changes in 20 European populations. We also estimate the effect of a change in the educational distribution on the overall level of mortality. We use national data on risk factor prevalence and mortality, and rate ratios from epidemiologic reviews on the impact of risk factors on mortality. The scenarios where the whole population has the same prevalence of physical activity, smoking and BMI as the high educated show that excess mortality of low educated persons would drop by 2 to 49 percent. A redistribution of income results in smaller reductions of inequalities. We present a promising tool for quantifying the effect of policy interventions on health inequality.

Introduction

Inequalities in health between socioeconomic groups are increasingly recognized as one of the main challenges for health policy (see discussion in Marmot, 2005). Studies from Europe have shown that health inequalities are substantial, but that there are important variations between countries in the magnitude of health inequalities (Mackenbach et al. 2008; Eikemo et al. 2008; Hoffmann 2011a), suggesting great scope for reducing health inequalities. In 2005, the WHO established the Commission on Social Determinants of Health (CSDH) to provide advice on how to reduce socioeconomic inequalities in health. However, it is currently unknown to what extent they are actually modifiable, which is a serious barrier for effective policy-making, because it hinders both priority setting and the formulation of realistic quantitative targets for reducing health inequalities. Moreover, until recently, existing methods have not been applied to quantify the impact on health inequalities of modifying the distribution of specific risk factors. We use a methodology applied within the Global Burden of Disease (GBD) study, which links risk factors to health outcomes through the Population Attributable Fraction (PAF), and adapt it to the study of social inequalities in mortality. The PAF estimates the proportion of a population health outcome that is attributable to a particular exposure, or in other words, the proportion by which a health outcome would be reduced if exposure to a particular risk factor was changed. We apply the PAF methodology to the problem of socioeconomic inequalities in mortality on the basis of several types of counterfactual scenarios using data from 20 European populations. These populations have different welfare arrangements (Eikemo & Bambra 2008), and also differ by educational structure, by the prevalence of risk factors, and by the magnitude of health inequalities. Among the scenarios are, first, educational scenarios in which the educational distribution changes: a) everyone has high education (theoretical maximum), b) the country with the best educational distribution is chosen as a model for best practice. Second, we calculate risk factor scenarios in which the distribution of proximate risk factors change: the risk factor prevalence in the whole population will be as it is in the highest educational group. We analyze all scenarios in terms of their impact on the level of total mortality and in addition we analyzes the risk factor scenarios in terms of their impact on educational differences in mortality, for each risk factor separately and combined.

Data

This study covers 20 populations from 17 different European countries. We aimed at using national data but for Spain we had to study three cities/regions (Barcelona, Madrid, Basque country), for Belgium we only study Brussels and for Italy we analyze Turin and the Tuscany region. We use data on the prevalences of the proximate risk factors low physical activity, smoking, high BMI and low income stratified by educational level. This data comes from national health interview surveys (NHS) around the year 2000, except for income data for Finland, France, Netherlands, Poland, Sweden and Switzerland that comes from the European Social Survey (ESS) and smoking prevalences for Austria that is from the European Community Household Panel (ECHP). The large amount of prevalence data by risk factor, gender, age, education and country are not included in this paper due to space limitations, but are available upon request. Secondly, we use information on mortality rate ratios for the impact of the risk factors on mortality from several published studies and literature reviews (see Table 1). Thirdly, we use mortality data from national statistical offices which contains information on gender, age and educational attainment (see Table 2). This data source also provided us with the prevalence of low education (the educational distribution of a population) and the relative risk of mortality between educational groups. We stratify our analysis by gender, four age groups (30–44, 45–59, 60–69, 70–79) and three educational levels: (1) primary and lower secondary education (ISCED-levels 0-2), (2) higher secondary education (ISCED 3), and (3) post secondary and tertiary education (ISCED 4-6).

Methods

To address the types of scenarios presented above, we use the Population Attributable Fraction to assess the expected changes in mortality that would result from modifying the population distribution of exposure to a risk factor. This method from the field of Comparative Risk Assessment methods (Formula 1) is adapted to estimate the impact of counterfactual distributions of specific risk factors on the overall level of mortality and on educational differences in mortality. The latter is achieved by stratifying the PAF calculation by educational group. Many diseases are caused by multiple risk factors. In order to estimate this multicausal impact, Formula 2 is used that assumes that the risk factors are not correlated and that there is no mediation of one risk factor by another risk factor (Gakidou et al. 2007).

Formula 1: $$PAF = \frac{\sum_{i=1}^{n} P_i RR_i - \sum_{i=1}^{n} P'_i RR_i}{\sum_{i=1}^{n} P_i RR_i}$$

Formula 2: $$PAF = 1 - \prod_{i=1}^{n} (1 - PAF_i)$$

$\boldsymbol{n}$ = number of exposure categories
$\boldsymbol{P_i}$ = proportion of population currently in the ith exposure category
$\boldsymbol{P'_i}$ = proportion of population in the ith exposure category in the counterfactual (alternative) scenario
$\boldsymbol{RR_i}$ = relative mortality risk for the ith exposure category
$\boldsymbol{PAF_i}$ = the proportion of the disease preventable by reducing exposure to the ith risk factor.
The product of all (1-PAF_i)'s represents the fraction of disease not preventable through interventions on any of the *n* risk factors.

There are substantial differences between men and women in how educational status relates to health (Hoffmann 2008) and in the determinants of educational inequalities in health (Schrijvers et al. 1999). Also, the impact of risk factors on mortality is different in different stages of the life course (Danaei et al. 2009; Hoffmann 2011b). Thus, in order to obtain accurate estimates the analyses were stratified by gender and age by using gender and age specific prevalences and mortality rates. If available from the literature reviews we also used gender and age specific rate ratios for the impact of risk factors on mortality (see Table 1). We present only the results for all ages that are based on the age-specific calculations by summing up the saved deaths across age categories and then calculating a new PAF for all ages together. In rare cases where the scenario of applying the risk factor prevalence of the high educated to the population as a whole would lead to a mortality increase in lower educated groups (because of an inverse social gradient of risk factor prevalence) we decided to ignore this deterioration because it is implausible that a policy intervention would make health behaviour worse.

Results

We show, first, results for risk factor scenarios in which we assume that the risk factor prevalence for the whole population would be as among the highly educated. We show this scenario for physical activity, BMI, smoking (separately and combined) and for income in order to compare the effect of changes in behaviour to the effect of a change in the income distribution. The risk factor scenarios can be analyzed both in terms of their impact on the overall level of mortality and in terms of their impact on health inequality. Second, we show two educational scenarios: a) everyone has high education and b) the educational distribution is as in the best-practice country (Norway). The educational scenarios can only be analysed in terms of their impact on the overall level of mortality (because we do not assume any change in mortality differentials between educational groups.

To address the potential reduction of overall mortality in all scenarios, Table 3 presents the Population Attributable Fraction in percent for each scenario by gender and country. For understanding the meaning of the different PAF values it is noteworthy that their size depends on two factors: first, the degree of social inequality in risk factor prevalence (how much change does the scenario imply), second, the impact of the risk factor on mortality (rate ratio). In the scenario where the prevalence of physical activity would be as among the highly educated we see a total reduction of mortality between 0.1 percent (Finish women) and 4.7 percent (women in Brussels). The analogous smoking scenario would lead to a maximum mortality reduction of 8.1 percent (men in England & Wales) and the BMI scenario has a maximum mortality reduction of 3.7 percent (women in Tuscany). If we look at the combined effect of our three behavioral risk factors the maximum mortality reduction is found among men in England & Wales (9.2 percent), although in this case the effect of physical activity could not be included because of missing prevalence data. The analogous effect of a redistribution of income is a mortality reduction between 2 percent (Swedish women) and 8.5 percent (men in Hungary). The educational scenario S2 in which the "best-practice" educational distribution of Norway is assumed, we see mortality reductions between 0.4 percent (women in Lithuania) and 18.5 percent (men in Hungary). For men in Switzerland we see a negative mortality reduction which means that their educational distribution would deteriorate if changed to the Norwegian educational distribution. The highest mortality reduction occurs in the maximum potential scenario S3 in which every person has high education. Under this extreme and theoretical assumption we would see mortality reductions between 9.6 percent (women in Turin) and 54.1 percent (men in Hungary and Poland).

The risk factor scenarios on physical activity, smoking, BMI and income can also be analysed in terms of a potential reduction of social inequality in mortality. In the first two columns of Table 4, we present the current mortality rate ratios for low and mid educated persons compared to high educated persons. In the following columns we look at the reduction of mortality inequality in scenarios where we remove social difference in risk factor prevalence (for each risk factor separately and for our three behavioral risk factors factors combined). For example, if physical activity, smoking and BMI were as prevalent as among the high educated, we would see a decline of the mortality rate ratio of low compared to high educated persons from 1.71 to 1.48 among Danish men which is a decline of 33 percent. The effect of the income scenario on health inequality is slightly more modest in most countries: Looking again at Danish men, leveling the income distribution across educational groups would decrease health inequality by 19 percent.

Figure 1 provides a graphical presentation of the impact of the combined behavioral scenario (physical activity, smoking BMI) and the income scenario on health inequality, compared to the current mortality rate ratios between low and high educated. We see, first, that Eastern European countries have higher health inequality, southern countries have lowest inequality and Nordic and Western countries take an intermediate position. Second, the combined behavioral scenario can reduce health inequality substantially in most countries, only for women in Austria and France this scenario does not change health inequality. Third, comparing the impact of the behavioral scenario to the income scenario, we see an inconsistent pattern: among men the impact is very similar between these two scenarios in about one third of the countries. In another third the income scenario reduces health inequality more and in one third the behavioral scenario reduces health inequality more. Among women, most countries show a higher impact of the behavioral scenario.

Discussion

We have shown how the PAF approach can be used to calculate the impact of changes in the social distribution of proximate risk factors, first on mortality, and second on the magnitude of socioeconomic inequalities in mortality in different countries. The fraction of all-cause mortality preventable by a redistribution of physical activity, smoking and BMI to the level observed among the higher education is typically between 5 and 10 percent for men, and somewhat lower for women. There are large variations between countries, gender and contributions of separate risk factors. In the same scenario inequalities in mortality can potentially be reduced for both men and women, but not sufficiently to eliminate them. On average, the inequality-reducing impact of the income scenario stays below the impact of the behavioral scenario. This surprisingly small impact of the income scenario is due to our choice of rate ratios for the impact of low income on mortality. Other studies have reported a much higher impact of income on mortality even if controlled for a number of confounders (Hoffmann 2011a). However, the problem of causality and confounding while measuring the impact of income on mortality is not definitely solved yet. Thus we consider the results for the income scenario to be preliminary.

Although not exactly comparable, other studies show results of a similar order of magnitude: leveling both smoking behavior and physical activity could reduce inequality in mortality by 25 percent for men and women combined in the Netherlands (van Oort et al. 2005) and smoking behaviour alone reduces inequality by 32 percent in England (Stringhini et al. 2010). Laaksonen et al. (2008) show that levelling physical activity could reduce inequality for both lowest and middle educated by 14 and 9 percent, men and women respectively, and levelling smoking behaviour reduces inequality for the lowest educated by 28 percent among men and 22 percent among women. The main advantage of the PAF approach is that it can combine data from different sources, while a regression necessarily measures the risk exposure and the outcome in the same sample. This is not an advantage as such, but in many situations country specific data on both exposure and impact is not available. Moreover rate ratios from large literature reviews (as used in our study) might be more accurate than small national surveys. In the following we discuss specific limitations of our study and assumptions inherent to the PAF methodology.

First, the categories used in the prevalence data and the categories for which the RRs are found in the literature sometimes differed between countries and had to be harmonized. Second, the relative risks for the proximate risk factors are assumed to be the same for all three countries (Walter 1976). This assumption is necessary for practical reasons, simply because there are no high quality literature reviews on the impact of risk factors for each country. Here again, we rely on the Global Burden of Disease project. There is an increasing body of evidence stating that, when the metric of exposure is comparable, the RRs are similar across populations in different world regions (GBD Study Operations Manual 2009). Third, the relative risks of the proximate risk factors are assumed to be the same for all educational groups. Whether a rate ratio for e.g. smoking can be regarded as a biological constant or whether the impact of smoking differs between socioeconomic groups is still an open question (Gunning-Schepers 1998). Evidence from the Whitehall II study suggests, that smoking is more harmful for those placed lower in the social hierarchy (Marmot & McDowall 1986) and evidence from New Zealand shows that the impact of smoking on mortality varies over time and by ethnicity (Hunt et al. 2005) but again there is no systematic evidence on how the impact of proximate risk factors would differ by socioeconomic group. Fourth, we did not calculate confidence intervals for the results. This would be possible by calculating standard errors for the normal distributions of log-rate-ratios and for the binomial distributions of prevalences, using number of deaths and sample sized respectively. With bootstrapping one could obtain the standard error and confidence intervals of the resulting PAF distribution. However, besides a relatively large amount of computational work the possibility to calculate confidence intervals depend on the availability of the background information mentioned above, which, unfortunately, is almost never reported in published articles. To search for this underlying data from the studies that published the mortality rate ratios is beyond the scope of this article.

While the PAF involves a relatively simple calculation and methodology, it is based on a number of assumptions. The first fundamental assumption of the PAF approach is that the relative risks used in the PAF calculation accurately reflect the causal effects of the risk factors on mortality (Walter 1976; Northridge 1995; Levine 2007). We consider the assumption of causality from the proximate risk factor to mortality to be unproblematic because we relied on systematic reviews that have tried to filter out the causal relationship between risk factors and mortality. The more uncertain causality from education to risk factors does not have to be assumed here because we simply show the effect of redistributing risk factors but we do not interpret our results as an explanation of health inequalities. Secondly, the multicausal relationship in Equation 2 is based on the assumption that exposures to risks are uncorrelated. In the present paper we can only account for the correlation with education by stratifying the analysis by educational group. Equation 2 also assumes that the effect of one risk factor is not mediated through another risk factor (Walter 1983). In reality it is likely that changing the distribution of one risk factor will also affect the distribution of other risk factors. As noted above, this potential bias has been partly corrected by adjusted RRs provided by other projects. For the close relation between physical activity and BMI there remains uncertainty whether all bias has been removed because we had to use rate ratios from several studies using different correction methods.

To conclude, our analysis of proximate risk factors shows the extent to which health inequalities can realistically be reduced by interventions on proximate risk factors. Such interventions may have targets that are more or less ambitious than the ones we have assumed here (health behaviour as in the highest educational group). But for policy setting it is crucial to know the gender and country specific effects of an intervention on health inequality, a flexibility which is offered using the PAF approach.

References

Danaei, G., Ding, E. L., Mozaffarian, D., Taylor, B., Rehm, J., Murray, C. J. L., et al. (2009). The Preventable Causes of Death in the United States: Comparative Risk Assessment of Dietary, Lifestyle, and Metabolic Risk Factors. PLoS Med, 6(4), 1-23.

Eikemo, T. A., & Bambra, C. (2008). The welfare state: a glossary for public health. J Epidemiol Community Health, 62, 3-6.

Eikemo, T. A., Huisman, M., Bambra, C., & Kunst, A. E. (2008). Health inequalities according to educational level in different welfare regimes: a comparison of 23 European countries. Sociology of Health & Illness, 30(4), 565-582.

Gakidou, E., Oza, S., Cecilia, S. B., Fuertes, V., Li, A. Y., Lee, D. K., et al. (2007). Improving Child Survival Through Environmental and Nutritional Interventions. The Importance of Targeting Interventions Toward the Poor. JAMA, 298(16), 1876-1887.

GBD Study Operations Manual (2009). Harvard University, University of Washington, John Hopkins University, University of Queensland, World Health Organization.

Gunning-Schepers, L. (1998). The health benefits of prevention. Rotterdam: Erasmus Medical Center, Dissertation.

Hoffmann, R. (2008). Socioeconomic Differences in Old Age Mortality. Dordrecht: Springer.

Hoffmann, R. (2011a). Socioeconomic Inequalities in Old-Age Mortality: A comparison of Denmark and the USA, Soc Sci Med, 72(12), 1986-1992.

Hoffmann, R. (2011b). Illness, not age, is the leveler of social mortality differences in old age. J Gerontol B Psychol Sci Soc Sci, 66B(3), 374-379.

Hunt, D., Blakely, T., Woodward, A., Wilson, N. (2005). The smoking-mortality association varies over time and by ethnicity in New Zealand. Int J Epidemiol, 34, 1020-1028.

Laaksonen, M., Talala, K., Martelin, T., et al. (2008). Health behaviours as explanations for educational level differences in cardiovascular and all-cause mortality: a follow-up of 60000 men and women over 23 years. Eur J Public Health, 18, 38-43.

Levine, B. (2007). What does the population attributable fraction mean? Prev Chronic Dis, 4(1), 1-5.

Lhachimi, S. K., Nusselder, W. J., Mackenbach, J.P., et al. (2012). Introducing DYNAMO-HIA – A dynamic modeling tool for generic health impact assessments. PloS ONE, forthcoming.

Mackenbach, J. P., Stirbu, I., Roskam, A.-J. R., Schaap, M. M., Menvielle, G., Leinsalu, M., et al. (2008). Socioeconomic Inequalities in Health in 22 European Countries. N Engl J Med 358, 2468-2481.

Marmot, M. (2005). Social determinants of health inequalities, Lancet, 365(9464), 1099-1104.

Marmot, M. G., McDowall, M. E. (1986). Mortality decline and widening social inequalities. Lancet, 2**,** 274-276.

Martikainen, P., Valkonen, T., et al. (2009). The effects of individual taxable income, household taxable income, and household disposable income on mortality in Finland, 1998-2004. Populaiton Studies, 63(2), 147-162.

Nocon, M., T. Hiemann, et al. (2008). Association of physical activity with all-cause and cardiovascular mortality: a systematic review and meta-analysis. Journal of Cardiovascular Risk, 15(3), 239-246.

Northridge, M E. (1995). Public health methods - attributable risk as a link between causality and public health action. Am J Public Health, 85, 1202-1204.

Schrijvers, C. T. M., Stronks, K., van de Mheen, H. D., & Mackenbach, J. P. (1999). Explaining Educational Differences in Mortality: The Role of Behavioral and Material Factors. American Journal of Public Health, 89(4), 535-540.

Stringhini, S., Sabia, S., Shipley, M., et al. (2010). Association of socioeconomic position with health behaviors and mortality. JAMA, 303, 1159-66.

Thun, M. J., Day-Lally, C., Myers, D. G., et al. (1997). Trends in tobacco smoking and mortality from cigarette use in Cancer Prevention Studies I (1959 through 1965) and II (1982 through 1988). In: Changes in cigarette-related disease risks and their implication for prevention and control. Smoking and Tobacco Control Monograph 8. Bethesda, MD: US Department of Health and Human Services, Public Health Service, National Institutes of Health, National Cancer Institute, 305–382. NIH Publication no. 97–1213.

van Oort, F. V. A., van Lenthe, F. J., Mackenbach, J. P. (2005). Material, psychosocial, and behavioural factors in the explanation of educational inequalities in mortality in the Netherlands. J Epidemiol Community Health; 59, 214–220.

Walter, S. D. (1976). Estimation and interpretation of attributable risk in health research. Biometrics, 32, 829-49.

Walter, S. D. (1983). Effects of interaction, confounding and observational error on attributable risk estimation. Am J Epidemiol, 117, 598-604.

Table 1: Rate ratios for the impact of risk factors on all-cause mortality

	MEN				WOMEN			
	age 30-44	age 45-59	age 60-69	age 70-79	age 30-44	age 45-59	age 60-69	age 70-79
Physical Activity								
sedentary	1.28	1.28	1.28	1.28	1.54	1.54	1.54	1.54
active	1	1	1	1	1	1	1	1
Smoking								
current	2.07	2.07	2.07	2.07	1.74	1.74	1.74	1.74
former	1.35	1.35	1.35	1.35	1.23	1.23	1.23	1.23
never	1	1	1	1	1	1	1	1
BMI								
30+	1.55	1.52	1.41	1.30	1.50	1.47	1.36	1.20
25-30	1.20	1.19	1.15	1.12	1.15	1.14	1.12	1.10
-25	1	1	1	1	1	1	1	1
Income								
lowest quart.	1.29	1.29	1.29	1.29	1.19	1.19	1.19	1.19
second quart.	1.16	1.16	1.16	1.16	1.08	1.08	1.08	1.08
third quart.	1.08	1.08	1.08	1.08	1.05	1.05	1.05	1.05
highest quart.	1	1	1	1	1	1	1	1

Sources: physical activity: Nocon et al. 2008; income: data as used in Martikainen et al. 2009, but the authors provided us with recalculated rate ratios for income quartiles; BMI: Dynamo-HIA project (Lhachimi et al. 2012); smoking: Thun et al. 1997, results taken from related website: https://apps.nccd.cdc.gov/sammec/login.asp.

Table 2: Characteristics of the mortality data

Population	Type of dataset	Period	Geographic coverage	Demographic coverage
Austria	longitudinal	2001-2002	National	whole population
Barcelona	cross-sectional, linked	2000-2006	Urban	whole population
Basque region	longitudinal	2001-2006	Regional	whole population
Brussels	longitudinal	2001-2004	Urban	whole population
Czech rep.	cross-sectional	1999-2003	National	whole population
Denmark	longitudinal	2001-2005	National	whole population
England & Wales	longitudinal	2001-2006	National	1% of the population
Estonia	cross-sectional	1998-2002	National	whole population
Finland	longitudinal	2001-2007	National	20% of Finns are excluded (at random)
France	longitudinal	1999-2005	National	1% of the population. Born outside France mainland excluded
Hungary	cross-sectional	1999-2001	National	whole population
Lithuania	longitudinal	2001-2005	National	whole population
Madrid	cross-sectional, linked	2001-2003	Regional	whole population
Netherlands	longitudinal	1998-2007	National	from labour force survey
Norway	longitudinal	2001-2006	National	whole population
Poland	cross-sectional	2001-2003	National	whole population
Scotland	longitudinal	2001-2006	National	whole population
Sweden	longitudinal	2001-2006	National	whole population
Switzerland	longitudinal	2001-2005	National	Non-Swiss nationals excluded
Turin	longitudinal	2001-2006	Urban	whole population
Tuscany	longitudinal	2001-2005	Florence,Leghorn,Prato	whole population

Table 3: Population Attributable Fraction (in %) of all-cause mortality for different scenarios

Scenario	S1					S2	S3
Risk Factor	low physic. activity	smoking	high BMI	all 3 behaviors combined	low income	education	education
MEN							
Austria	no PR	6.1	no PR	6.1	no PR	1.9	34.2
Barcelona	1.9	2.1	1.5	5.3	no PR	9.1	25.8
Basque	2.0	2.0	0.8	4.6	no PR	8.9	22
Brussels	1.7	2.2	1.9	5.6	5.8	3.7	35.3
Denmark	1.3	5.8	2.4	9.1	5.7	4.0	30.8
England&Wales	no PR	8.1	1.2	9.2	6.1	8.8	31.5
Estonia	1.0	7.4	0.1	8.4	no PR	6.1	48.6
Finland	0.5	5.3	0.7	6.4	6.9	4.9	37.2
France	no PR	2.1	no PR	2.1	8.0	8.8	45.1
Hungary	no PR	0.9	1.0	2.0	8.5	18.5	54.1
Lithuania	1.7	5.2	1.1	7.8	no PR	6.5	44.3
Madrid	1.9	1.9	1.5	5.1	no PR	6.3	23.1
Netherlands	0.9	3.2	1.7	5.7	6.0	1.8	30.5
Norway	1.5	no PR	2.2	3.7	5.8	Reference	36
Poland	no PR	no PR	no PR	no PR	8.3	7.0	54.1
Scotland	no PR	no PR	no PR	no PR	no PR	6.0	38.5
Sweden	no PR	5.7	1.8	7.4	5.3	4.1	32
Switzerland	1.5	1.7	2.0	5.1	5.5	-5.7	29.9
Turin	0.8	1.5	2.2	4.3	no PR	11.4	28.2
Tuscany	0.8	1.4	2.2	4.3	no PR	11.8	31.8
WOMEN							
Austria	no PR	1.9	no PR	1.9	no PR	5.5	26
Barcelona	2.0	0.4	3.4	5.7	no PR	7.5	19.7
Basque	2.1	0.7	3.2	5.9	no PR	5.0	13.1
Brussels	4.7	0.6	3.0	8.0	3.4	3.6	29.6
Denmark	3.2	2.6	2.2	7.7	2.9	5.3	30.3
England&Wales	no PR	4.2	2.5	6.5	3.9	9.7	29.6
Estonia	3.3	3.1	2.4	8.6	no PR	0.8	41.4
Finland	0.1	2.3	2.4	4.7	3.0	3.2	30
France	no PR	0.7	no PR	0.7	4.9	7.4	30
Hungary	no PR	0.0	3.1	3.1	4.7	14.9	32
Lithuania	2.8	0.7	1.2	6.3	no PR	0.4	35.4
Madrid	1.9	0.4	3.3	5.4	no PR	2.4	19.2
Netherlands	2.6	1.7	2.4	6.6	3.4	7.1	25.7
Norway	1.3	no PR	2.0	3.2	3.5	Reference	32.5
Poland	no PR	no PR	no PR	no PR	3.1	5.7	42.9
Scotland	no PR	no PR	no PR	no PR	no PR	7.9	35.3
Sweden	no PR	3.1	1.6	4.6	2.0	1.2	32.4
Switzerland	2.2	0.6	3.0	5.6	2.8	1.9	20.9
Turin	1.4	0.2	3.0	4.4	no PR	3.2	9.6
Tuscany	1.8	0.3	3.7	5.6	no PR	6.5	17.6

no PR = PAF-calculation not possible because no (reliable) prevalence data available
Scenario 1: Risk factor distribution as among the highly educated
Scenario 2: Educational distribution as in Norway (best practice country)
Scenario 3: The whole population has high education

Table 4: All-cause mortality rate ratios (RRs) for educational groups, scenario RRs, and percentage reduction of inequality ("red") in the scenario that the prevalence of physical activity, smoking, BMI (separately and combined) and income would be distributed as in the highest educational group

	RR		$RR_{Physical\ activity}$				$RR_{Smoking}$				RR_{BMI}				$RR_{all\ 3\ factors\ combined}$				RR_{income}			
Education	low	mid	low	red	mid	red	low	red	mid	red	low	red	mid	red	low	red	mid	red	low	red	mid	red
MEN																						
Austria	1.86	1.49					1.77	11	1.37	24					1.77	11	1.37	24				
Barcelona	1.54	1.16	1.49	8	1.15	10	1.50	7	1.14	16	1.50	7	1.16	4	1.42	21	1.11	29				
Basque	1.40	1.12	1.36	9	1.11	12	1.36	9	1.11	11	1.38	4	1.12	2	1.31	22	1.09	25				
Brussels	1.85	1.45	1.80	6	1.45	2	1.79	7	1.43	6	1.80	6	1.43	6	1.70	18	1.39	14				
Denmark	1.71	1.39	1.67	6	1.38	2	1.57	20	1.32	18	1.65	8	1.36	8	1.48	33	1.29	27	1.58	19	1.31	20
Engl&W	1.69	1.23					1.51	26	1.15	34	1.66	4	1.23	3	1.48	30	1.15	37	1.55	21	1.19	20
Estonia	2.48	1.89	2.44	2	1.87	2	2.27	14	1.74	17	2.47	0	1.89	0	2.23	17	1.72	18				
Finland	1.95	1.49	1.93	2	1.49	1	1.79	17	1.43	12	1.92	2	1.49	1	1.76	20	1.42	14	1.76	20	1.40	20
France	2.20	1.62					2.14	5	1.60	4					2.14	5	1.60	4	1.99	18	1.49	21
Hungary	2.99	1.45					2.97	1	1.43	4	2.96	2	1.43	4	2.93	3	1.41	8	2.68	16	1.36	21
Lithuania	2.34	1.64	2.26	6	1.63	2	2.15	14	1.58	10	2.32	1	1.62	4	2.06	21	1.54	16				
Madrid	1.42	1.22	1.38	9	1.20	8	1.39	8	1.19	12	1.39	8	1.21	3	1.32	24	1.17	22				
Netherl.	1.79	1.34	1.77	2	1.33	5	1.69	12	1.31	9	1.73	7	1.33	4	1.62	21	1.28	18	1.63	20	1.26	24
Norway	2.10	1.48	2.06	4	1.46	5					2.05	5	1.44	8	2.00	9	1.42	13	1.91	18	1.40	18
Poland	2.79	2.10																	2.51	16	1.93	15
Scotland	2.03	1.45																				
Sweden	1.76	1.37					1.62	19	1.30	20	1.72	5	1.34	8	1.58	23	1.27	27	1.60	21	1.32	15
Switzerl.	2.04	1.43	1.96	8	1.41	4	1.94	10	1.41	4	1.97	7	1.39	7	1.80	23	1.36	15	1.85	18	1.33	22
Turin	1.56	1.15	1.54	3	1.15	1	1.54	5	1.13	12	1.52	8	1.13	9	1.47	16	1.11	22				
Tuscany	1.64	1.22	1.62	3	1.22	1	1.61	4	1.2	8	1.59	7	1.21	6	1.55	14	1.19	15				
WOMEN																						
Austria	1.51	1.19					1.50	2	1.15	22					1.50	2	1.15	22				
Barcelona	1.35	1.08	1.31	11	1.07	9	1.34	2	1.07	5	1.28	19	1.07	7	1.24	31	1.06	21				
Basque	1.20	1.06	1.17	17	1.05	12	1.20	4	1.04	28	1.15	25	1.04	29	1.11	45	1.02	69				
Brussels	1.61	1.30	1.50	19	1.27	10	1.60	2	1.29	3	1.54	11	1.28	8	1.42	31	1.24	20	1.53	13	1.28	9
Denmark	1.66	1.28	1.59	11	1.24	12	1.60	9	1.26	8	1.61	8	1.26	6	1.48	27	1.21	26	1.60	10	1.25	10
Engl&W	1.62	1.10					1.52	16	1.09	12	1.56	9	1.09	11	1.47	24	1.08	23	1.53	14	1.08	19
Estonia	2.31	1.62	2.25	5	1.55	11	2.24	6	1.56	10	2.22	7	1.59	4	2.09	17	1.47	24				
Finland	1.77	1.28	1.77	1	1.28	0	1.71	8	1.26	8	1.72	7	1.24	15	1.65	16	1.22	22	1.69	10	1.24	13
France	1.61	1.26					1.59	2	1.25	3					1.59	2	1.25	3	1.50	17	1.21	18
Hungary	1.69	1.03					1.69	0	1.03	0	1.62	9	1.00	87	1.62	9	1.00	87	1.58	15	1.00	98
Lithuania	2.14	1.41	2.00	13	1.41	0	2.11	3	1.41	0	2.10	4	1.40	2	1.92	19	1.40	3				
Madrid	1.27	1.22	1.24	13	1.21	3	1.27	2	1.21	2	1.21	22	1.21	3	1.18	36	1.20	9				
Netherl.	1.54	1.11	1.49	9	1.08	26	1.51	6	1.10	15	1.49	10	1.09	18	1.41	25	1.05	58	1.47	13	1.08	27
Norway	1.94	1.32	1.90	5	1.31	4					1.88	6	1.29	8	1.84	11	1.28	11	1.83	12	1.28	13
Poland	2.03	1.62																	1.92	10	1.59	5
Scotland	1.95	1.19																				
Sweden	1.82	1.36					1.74	10	1.32	11	1.77	7	1.35	4	1.69	17	1.31	14	1.76	8	1.34	5
Switzerl.	1.53	1.13	1.44	17	1.13	1	1.52	2	1.13	4	1.46	14	1.11	20	1.36	32	1.10	25	1.45	14	1.11	15
Turin	1.14	1.06	1.12	15	1.06	5	1.14	2	1.06	2	1.10	33	1.05	17	1.07	49	1.05	23				
Tuscany	1.28	1.08	1.26	9	1.07	5	1.28	1	1.07	2	1.23	19	1.06	14	1.20	28	1.06	21				

Legend: RR = original rate ratio of mortality according to educational attainment; low = primary and lower secondary education compared to post secondary and tertiary education; mid = higher secondary education compared to post secondary and tertiary education; $RR_{risk\ factor}$ = new rate ratio after scenario has been applied to the risk factor in question. Blanks are missings due to missing prevalence data.

Figure 1:The potential reduction of health inequalities in two scenarios where (a) health behaviours and (b) material factors change their social distribution