MPIDR-NES Training Programme

Moscow, New Economic School,14th January - 1st February 2013

Population and Health

Лекция 11. Измерение неравенства: систематический обзор
Lecture 11. Measurement of inequalities: a systematic review

MAX PLANCK INSTITUTE FOR DEMOGRAPHIC RESEARCH
MAX-PLANCK-INSTITUT FÜR DEMOGRAFISCHE FORSCHUNG

РЭШ
Российская экономическая школа

Outline of the Lecture

- Basic considerations in measuring health inequalities
  - health status measures
  - population distributions across which comparisons are made
  - parametric and non-parametric ways to describe health distributions
  - absolute versus relative inequalities
- Health distributions and their visualization
- Single measures of inequality and their features

Why health inequalities do matter ?

Health inequalities are of a greater moral concern than the economic inequalities. While the latter one, are generally considered as “natural” and “unavoidable”, the former ones are considered as unfair and unacceptable. The idea is that societies should prevent transformation of economic inequalities into health inequalities.

Basic considerations. Health status measures.

Health measure should address a substantive research question and its distribution across dimensions of interest (individuals, households, demographic characteristics, income, areas etc) must be available.

Measures are characterized by <u>degree of their „measurability</u>“: dichotomous indexes signal about presence or absence of certain health/vital status. Ordinal measures: self-reported health, health scales, ADLs, stages of a disease etc. Continuous and cardinal measures: values or levels of blood pressure, cholesterol, heart rate, grip strength etc.

<u>Objectivity</u>. Reported data can be biased due to differences in understanding, norms and perceptions. These differences can be correlated with variables of interest. For example, in rich countries, poor people report greater illness and experience higher mortality, whereas In some poor countries (India, Ghana), the poor report less ill-health than the rich though the poor have higher mortality (Sen, 1994, Murray et al., 1992).

<u>Ability to highlight inequalities</u>. Some health measures tend to report greater inequality than others. Inequalities expressed in years of potential life lost in E&W in 1981 were more pronounced than if measured by death rates (Wagstaff et al., 1991). In general, measures of “potential life lost”, of “mortality amenable to medical intervention”, and of “health expectancy” produce especially steep social gradients (Macintyre, 1998, Wilkins and Adams, 1983).

Basic considerations. Population distributions across which comparisons are made.

The total health diversity and its socio-economic component.

Some authors claim that health research should be focused solely on socio-economic inequalities in health such as inequality by income, SES, etc. “Only those health inequalities that correlate with socio-economic inequalities are interesting” (Wagstaff et al., 1991, Wilkinson, 1991).

In fact, more general inequalities across individuals with no regard socio-economic labels are also important and interesting (Gakidou et al., 2001).

- Even if there is a strong wealth-health correlation, data on wealth does not provide full information about variation in health and vice versa. It is useful to know what part of health variation is not explained by known socio-economic factors. It signals about potential importance of hidden social or other factors such as variation in patterns of disease, cultural, regional, environmental, and bio-genetic factors.
- Continuous indicators of wealth and socio-economic labels of social groups are often biased or incomparable across time and countries (Illsey and Le Grand, 1987).

Therefore health inequality across population (individuals) can add important information to socio-economic health disparities.

Inter-individual and inter-group differences.

Operationally, there is a divide between inter-individual and inter-group differences. This distinction becomes less clear when there are many groups corresponding to individual’s characteristics and their categories.

Basic considerations. Parametric and non-parametric estimation of health distributions.

Distribution of health across population can be expressed in a classic way by means of group-specific mortality rates or rate ratios (non-parametric estimation).

Alternatively, one can regress the health outcome variable on socio-economic characteristic(s) and then express mortality rate ratios via the regression coefficients.

Each of the two estimation methods has its advantages and disadvantages. For example, the non-parametric estimation produces true empirical distributions, while the parametric estimates are produced by a model that could be imprecise. The parametric estimation produces more robust estimates for the cases when the number of population strata is high and the number of observations is limited.

The former method predominates in studies on large national populations with a small numbers of population strata, the latter in studies based on survey data or when the number of population strata is large.

Example: German men aged 65+ classified by East/West residence, type of medical insurance, type of occupation, type of medical insurance, and by pension income quintiles. German-pensioners-data (Retired-Germans.xls)

Examples. Distribution of mortality risk across population. An example of men in Finland in 1996-2000.

An example of two-dimensional education and marital status groups of Finnish males in 1996-2000:

1- Married with high education (HM), 2- never married with high education (HN), 3- divorced with high education (HD), 4- widowed with high education (HW), 5- married with secondary education (SM), 6- never married with secondary education (SN), 7- divorced with secondary education (SD), 8- widowed with secondary education (SW), 9- married with low education (LM), 10- never married with low education (LN), 11- divorced with low education (LD), and 12- widowed with low education (LW).

Non-parametric approach. Calculations of life expectancies, and standardized mortality ratios (SMRs) are problematic due to very small numbers in some groups that leads to random fluctuations.

Parametric approach. Expected mortality rate ratios (MRRs) derived by means of Poisson regression. The regression-based MRRs depict only principal features of mortality by age and group and are much less affected by random fluctuations than SMRs calculated according to the traditional approach.

An example of application on the Finnish data:

$$D(x, ed, ms) = P(x, ed, ms) \cdot \exp(\beta_0 + \beta_{ed} + \beta_{ms} + \beta_x),$$

D(*x,ed,ms*) and *P*(*x,ed,ms*) – deaths and population exposures in every multi-dimensional group,

β_0 - constant term,

$\beta_x, \beta_{ed}, \beta_{ms}$ - regression coefs. for mortality impacts of age, education, and marital status

Examples. Outcomes of Poisson regressions: independent effects of education and marital status

Outcomes of the Poisson regression with all explanatory variables included

Age	
age 30-34	0
age 35-39	0.43
age 40-44	0.90
age 45-49	1.30
age 50-54	1.68
age 55-59	2.07
age 60-64	2.48
age 65-69	2.99
age 70-74	3.47
age 75-79	3.96
age 80+	4.45

constant	-7.2635
Education	
(H) High	0
(S) Secondary	0.32
(L) Low	0.51
Marital status	
(N) Never married	0.63
(M) Married	0
(D) Divorced / separa	0.67
(W) Widowed	0.31

Reference categories: high education (education), married (marital status), and age group 30-34 (age).

Examples. Estimation of joint (total) effects of two variables on mortality.

The joint effect of several <u>independent</u> variables (e.g. education and marital status) can be estimated for each multidimensional population group i by summing β coefficients corresponding to categories of independent variables under consideration. In the case of Finland, the joint effect *(score)* of education and marital status *for each* of the 12 education-marital status groups is estimated by summing *β* coefficients for education and marital status.

$$score(ed, ms) = \beta_{ed} + \beta_{ms}$$

Cross-sectional *relative* mortality risks in each group *i* can be calculated as the following:

$$MRR\ (i) = \exp(score(ed(i), ms(i)) = \exp(score(i))$$

Note: one group should be chosen as a reference category. In our example we use mortality in the group of married with high education as the reference.

Examples. Estimation of mortality rate ratios for 12 education-marital status groups.

	β
Education	
(H) High	0
(S) Secondary	0.32
(L) Low	0.51
Marital status	
(N) Never married	0.63
(M) Married	0
(D) Divorced / separa	0.67
(W) Widowed	0.31

exp(0.32+0.63)

Group	*RR*
HM	1.00
HN	1.88
HD	1.95
HW	1.36
SN	2.59
SM	1.38
SD	2.68
SW	1.87
LN	3.13
LM	1.67
LD	3.25
LW	2.26

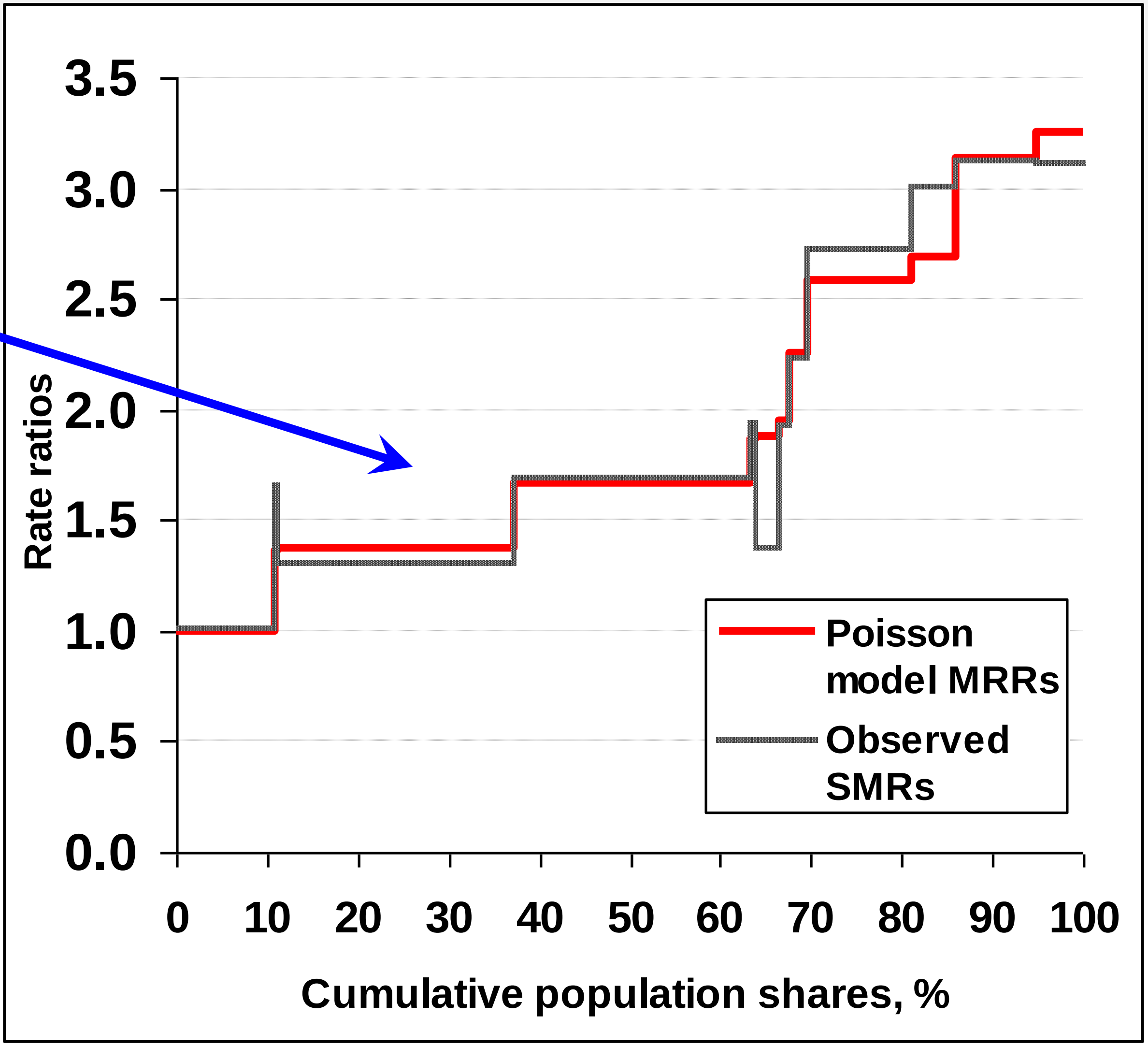
For a never married man with secondary education (SN), the model (Poisson regression) MRR is exp(0.32+0.63)=2.59

Examples. Model (Poisson regression-based) *MRR*s and empirical *SMR*s. 12 education-marital status groups, Finnish males

„Inequality steps“.

The 12 education-marstat groups are sorted in ascending order of the MRRs.

Their population shares are shown on the horizontal axis, the MRRs and empirical SMRs are shown on the vertical axis.

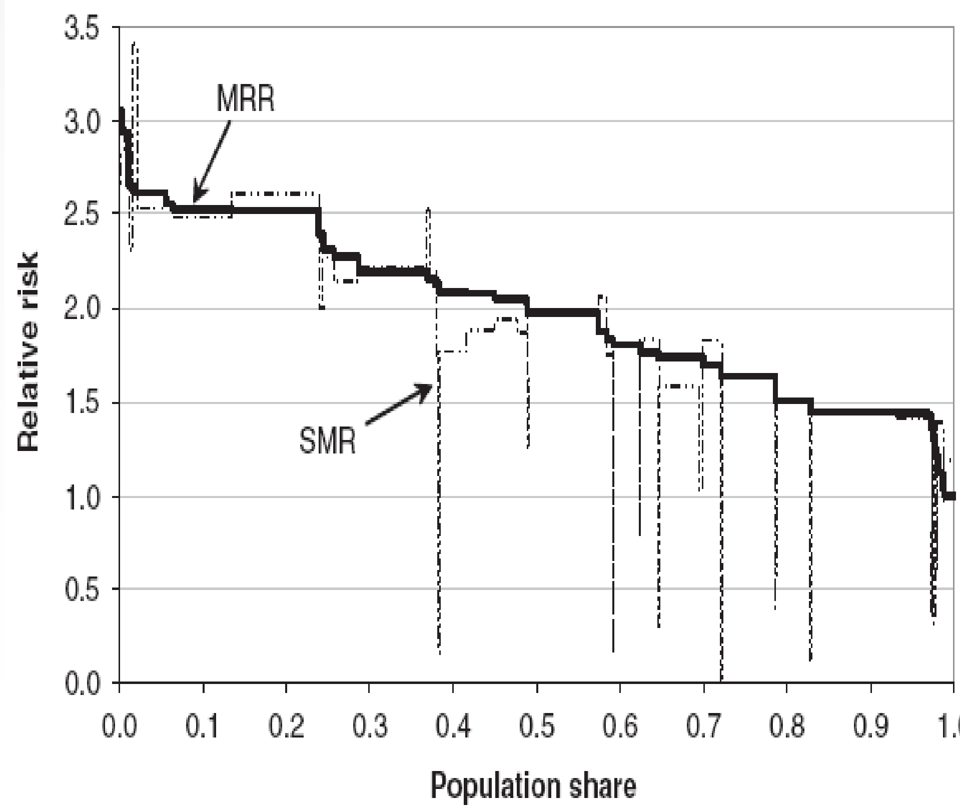


Examples. The study of five million retired German men aged 65+. 60 socio-economic groups.

Effects of residence, type of health insurance, occupational group, and life time earnings' quintile on mortality of German pensioners

	Population, ×1000	MRR, Model 2
Total	5100	–
Region		
Western	4036	1 (reference)
Easternt	1064	1.032 (1.022,1.043)
Health insurance		
Voluntary	666	1 (reference)
Mandatory	4434	1.402 (1.380,1.424)
Occupational group		
Manual workers	2694	1.222 (1.211,1.233)
Salaried employees	2091	1 (reference)
Miners	315	1.427 (1.404,1.450)
Quintiles of the earnings points' distribution		
1	914	1.382 (1.363,1.402)
2	1076	1.423 (1.404,1.404)
3	994	1.245 (1.228,1.263)
4	1068	1.127 (1.112,1.141)
5	1048	1 (reference)

Regression-based and empirical mortality rate ratios across all combinations of residence, type of health insurance, occupational group, and earnings points' quintile



Source: Shkolnikov et al., 2007.

Single measures of the amount of inequality

How one can judge whether the amount of the health disparity in one population is greater than that in the other or whether it increases or decreases with time?

An easiest way is to express disparity in each of the various health distributions in terms of single inequality measure. Higher or lower values of this measure would correspond to higher or lower amounts of disparity in health distributions.

There are numerous way to express disparities in a single value. Properties of inequality measures determine how this measure reflects detailed distributions of health.

Measures of inequality.
Absolute versus relative measures.

Relative measures of health inequality express the amount of health diversity relative to certain reference value (or norm). It could be a population average or level of health among individuals with the best (the worst) health. Relative measures are used more often due to their use in epidemiological methods.

Absolute measures express the amount of diversity in natural units: lost or saved lives, years of average length of life or of healthy life.

Absolute and relative inequality often lead to different judgments:

Table 1 Mortality from coronary heart disease among men age 35–64 by social class in England and Wales, selected years, 1976–92
(age-standardized rate per 100,000)

	1976–81	1986–92
Social classes		
Highest	246	160
Lowest	363	266
Rate ratio (lowest to highest classes)	1.48	1.66
Rate difference (lowest minus highest classes)	117	106

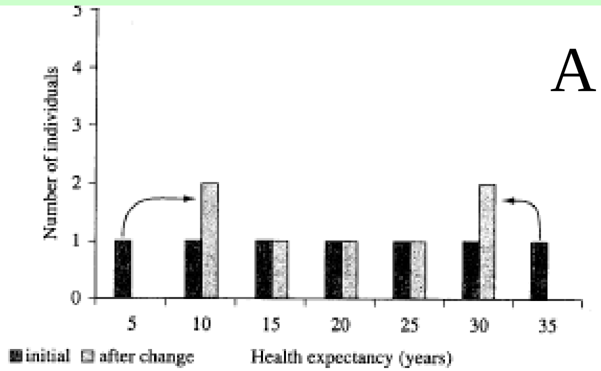
Source: Adapted from Drever and Whitehead 1997.

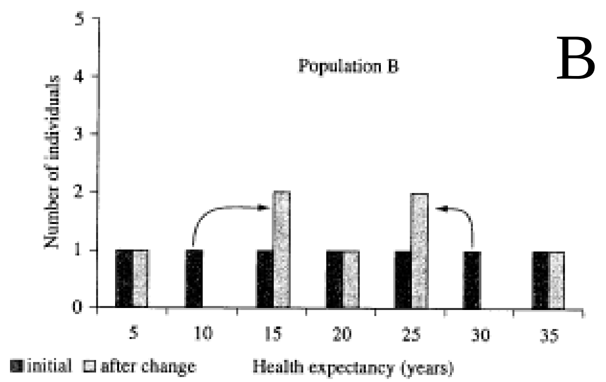
As mortality diminishes, relative inequality usually tends to increase. Imagine two population fractions with IMRs of 20 and 10 per 1000. So, the rate difference RD=10/1000 and the R ratio RR=2. After a reduction of IMR in both groups by 5/1000: RD=10/1000, but RR=15/5=3.

Measures of inequality. Aversion to inequality.

The sense of inequality measures is of a chief importance. The Le Grand and Rabin (1986) measure of inter-individual diversity showed that the inequality had lowered over the 1950s-70s, whereas the Black report showed that the social-class inequalities have widened. The contradiction was due to a different nature of the first measure that reflect inter-individual variation in longevity with no concern about social groupings.

Hypothetical example of health redistribution





Aversion to inequality.

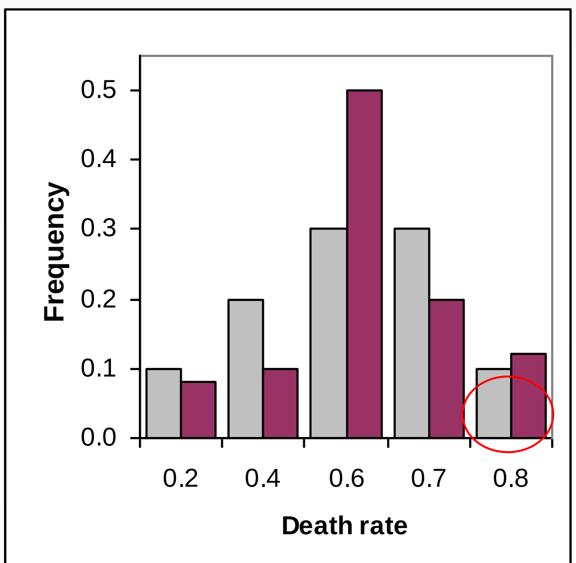
Consider two populations A and B of 7 individuals. Both of them have the same mean health expectancy equal to 20 years.
In A: 5 years of HE are transferred from individual with HE=35 to the one with HE=5. In B: 5 years are transferred from individual with HE=30 to the one with HE=10.
Some inequality measures evaluate transfers A and B as the equivalent ones. Other measures consider transfer A as a more equalizing one. The latter measures have greater *aversion* to inequality.

Source: Gakidou et al., 2001

Measures of inequality. Different judgments due to difference in aversion to inequality.

Inequality measures with different levels of aversion evaluate temporal changes and differences regarding amounts of inequality somewhat differently.

Consider two populations consisting of five groups (below) with mortality rates varying from 0.2 to 0.8. The second population (dark red) is characterized by greater shares of people at the average-mortality group and around than the second population (in gray). There is only one exception. The second population has slightly higher share of people in the highest-mortality group. Two inequality measures are used: the deviation from the mean and the quadratic deviation from the mean (STD). According to the first measure, population 2 has less inequality. According to measure 2, population 1 has slightly less inequality solely due to the higher share of people in the highest mortality group.



$$Meaure1 = \sum_i p_i \left| M_i - \overline{M} \right|$$

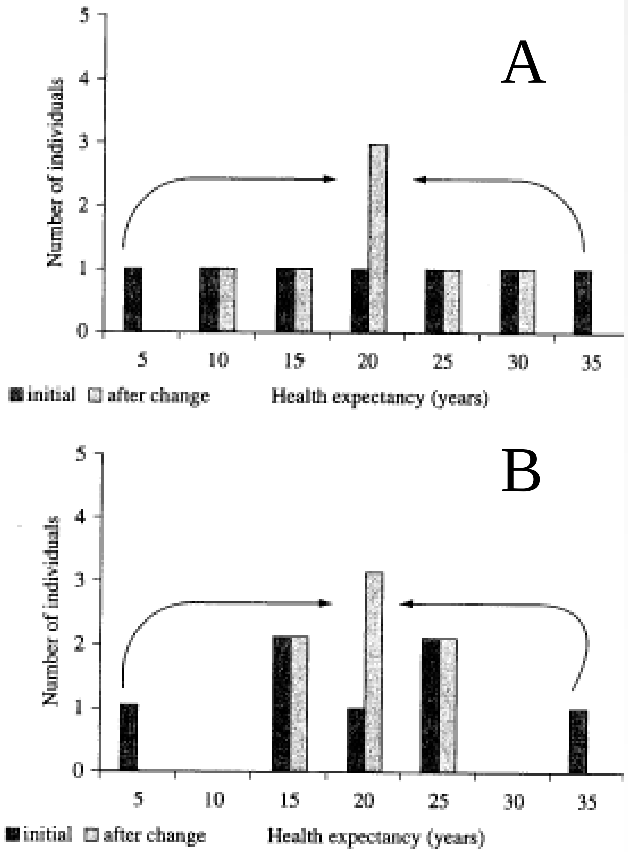
$$Meaure2 = \sqrt{\sum_i p_i \left(M_i - \overline{M} \right)^2}$$

	Population 1	Population 2
Measure 1	0.142	0.101
Measure 2	0.173	0.175

Example-different-ineq-aversion.xls

Measures of inequality.
Inter-individual vs. individual-mean differences.

Hypothetical example of health redistribution



<u>Individual-mean and inter-individual differences (standard deviation versus AID)</u>.

Distributions A and B have the same mean health expectancies of 20 years (both initially and after the transfer).

Transfers A and B redistribute the same amount of 15 years of healthy life from individual with HE=35 to the one with HE=5.

Inter-individual measures: scenario A represents a greater decrease in inequality (the shape of distribution matters).

Individual-mean measures: scenarios A and B are equivalent (only the redistributed amount matters).

Source: Gakidou et al., 2001

Range and statistical measures.

The most frequently encountered measures of inequality: absolute and relative ranges:

$$Range\_abs = \max_i (M_i) - \min_i (M_i),$$

$$Range\_rel = Range\_abs / \overline{M}$$

Interquartile range:

$$IQR = Q_{25} - Q_{75}$$

Standard deviation and coefficient of variation:

$$STD = \sqrt{\sum_i p_i (M_i - \overline{M})^2},$$

$$CoefVar = STD / \overline{M}$$

Index of dissimilarity.

This measure tells what part of mortality should be redistributed for reaching perfect equality at the average level.

$$ID = \frac{1}{2}\sum_i \left| \frac{p_i M_i}{\overline{M}} - p_i \right|$$

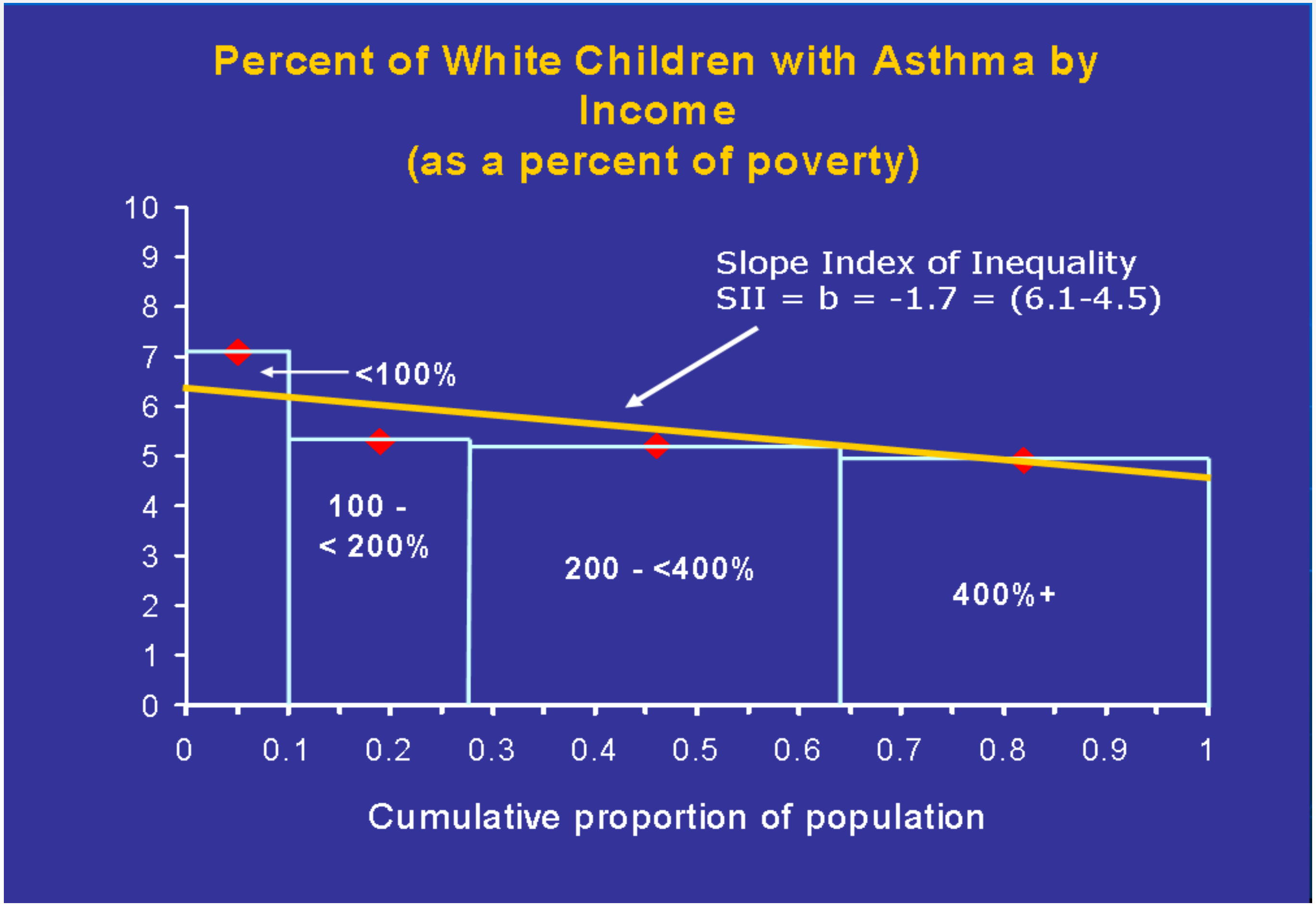
where p_i is the population share of group *i*, M_i is mortality or disease rate in this group, and *M*-cap is the mean mortality of the overall population.

The index is based on comparison of the group-specific death- and population-shares. The 1/2 multiplier ensures that *ID* varies from 0 to 1.

Slope and relative indices of inequality. Regression-based measures.

y – health outcome measure, x – cumulative popullation proportion.

OLS regression: $y = bx + c$



Presentation by Elsie Pamuk at

http://www.cdc.gov/ncphi/od/ai/conference/2007/Presentations/Thursday/P3_Thursday_Pamuk.ppt

Slope index and relative index of inequality (2).

SII = b = (y at x=1) – (y at x=0)

RII (mean) = SII/*mean* of y

mean of y = population value of y

Or

RII (ratio) = (y at x=1) / (y at x=0)

Presentation by Elsie Pamuk at
http://www.cdc.gov/ncphi/od/ai/conference/2007/Presentations/Thursday/P3_Thursday_Pamuk.ppt

SII estimation. Correction for heteroskedasticity -2.

Empirical values y_i of the health measure *y* are averages across individuals constituting group *i*. As the group sizes are unequal the usual assumption of the constant error variance can not be made. Thus, the original OLS regression should be replaced by the weighted least square regression with weights proportional to $\sqrt{n_i}$:

$$y_i\sqrt{n_i} = c\sqrt{n_i} + bx_i\sqrt{n_i}$$

instead of

$$y_i = c + bx_i$$

Population attributable fraction, a measure of public health impact.

Population attributable fraction is a proportion of all deaths (diseases, losses, etc.) that can be avoided if all population groups had the same rate of mortality (illness, disability, etc.) as the best health status group.

$$PAF = \frac{\sum_i p_i (RR_i - 1)}{\sum_i p_i RR_i},$$

where RR_i - mortality rate ratio for the group i, p_i - population weight of the group i.

In this formula:
the numerator = excess "deaths",
the denominator = all "deaths"

Absolute version of the same measure:

$$PAFabs = PAF \cdot \overline{M} \ ,$$

Measures of inequality. What share of deaths can be avoided if all groups experienced mortality of the "best" group?

Education-marital status group	Population share	MRR	MRR-1
HM	0.11	1.00	0.00
HW	0.00	1.36	0.36
SM	0.26	1.38	0.38
LM	0.26	1.67	0.67
SW	0.01	1.87	0.87
HN	0.03	1.88	0.88
HD	0.01	1.95	0.95
LW	0.02	2.26	1.26
SN	0.12	2.59	1.59
SD	0.05	2.68	1.68
LN	0.09	3.13	2.13
LD	0.05	3.25	2.25

$$PAF = \frac{\sum_i p_i (MRR_i - 1)}{\sum_i p_i MRR_i},$$

The best group in Finland:
married men with high education (HM)

PAF = 48%

References (1)

Anand, S. (1983). *Inequality and poverty in Malaysia. Measurement and decomposition.* New York: Oxford University Press.

Anand, S., Diderichsen, F., Evans, T., Shkolnikov, V., Wirth, M. (2001). Measuring disparities in health: methods and indicators. In: T. Evans, M. Whitehead, F. Diderichsen, A. Bhuiya, M. Wirth (Eds.), *Challenging inequities in health: from ethics to action*. New York: Oxford University Press.

Gakidou, E., Murray, Ch.J.L., Frenk, J. (2001). A framework for measuring health inequality. In: Ch.J.L. Murray, D.B. Evans (Eds.), *Health systems performance assessment: debates, methods, and empiricism*. Geneva: World Health Organization.

Illsey, R. & Le Grand, J. (1987). The measurement of inequality in health. In: A.Williams (Eds.), *Health and Economics* (pp. 13-36). London: Macmillan.

Kendall, M., Stuart, A. (1963). *The advanced theory of statistics*. London: Charles Griffen and Company.

Le Grand, J., Rabin, M. (1986). Trends in British health inequality 1931-1983. In: A.J. Culyer, B. Jonsson (Eds.), *Public and Private Health Services*. Oxford: Blackwell.

Macintyre, S. (1998). Social inequalities and health in the contemporary world: a comparative overview. In: S.S. Strickland, P.S. Shetty (Eds.), Human Biology and Social Inequality, 39th Symposium Volume of the Society for the Study of Human Biology. Cambridge: Cambridge University Press.

References (2)

Murray, C.J.L., Yang, G., Qiao, X. (1992). Adult mortality levels, patterns, and causes. In: R.G.S. Feachem et al. (Eds.), *The health of adults in developing world*. Oxford: Oxford University Press.

Sen, A. (1994). Objectivity and position: assessment of health and well-being. In: L.C. Chen, A. Kleinman, N.C. Ware (Eds.), *Health and Social Change in International Perspective*. Cambridge: Harward University Press.

Shkolnikov, V., Valkonen, T., Begun, A., Andreev (2001). Measuring inter-group inequalities in length of life. *Genus*, Vol. LVII (3-4), pp. 33-62.

Shkolnikov, V.M., Scholz, R., Jdanov, D.A., Stegmann, M., vion Gaudecker, M. (2007). Length of life and the pensions of five million retired German men. *The European Journal of Public Health*, doi:10.1093/eurpub/ckm102

Wagstaff, A., Paci, P., Doorslaer, E. (1991). On the measurement of inequalities of health. *Social Science and Medicine*, Vol. 33, pp.545-577.

Wilkins, R., Adams, O.B. (1983). Health expectancy in Canada, late 1970s: demographic, regional, and social dimensions. *American Journal of Public Health*, Vol. 73 (9), pp. 1073-1080.

Preston S.H., Elo I.T. (1995). Are Educational Differentials in Adult Mortality Increasing in the United States? Journal of Aging and Health, Vol. 7(4), pp. 476-496.