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ON THE MEASUREMENT
OF INFLUENCE
OF ALCOHOL ABUSE
ON POPULATION MORTALITY

Introduction

One of the negative effects of alcohol consumption is excessive mortality among alcohol abusers, so the measurement of the range of influence of alcohol abuse on mortality in a population is an important issue. The main purpose of the presented research is to find a measure allowing:
– to estimate the range of influence of alcohol abuse on mortality in a given population,
– to compare that range among different populations.

There are several well known characteristics of mortality of a population. The most often applied ones are:
– number of deaths,
– number of deaths from different causes,
– shares of deaths from different causes,
– crude mortality rates (general and cause specific),
– age adjusted mortality rates (general and cause specific),
– life tables biometric parameters, including: life expectancy at the age x (e_x), life expectancy for newborns (e_0, life tables containing the most important parameter), cause-elimination life tables biometric parameters.

The above mentioned characteristics give a lot of information about population mortality, however, some of their shortcomings could also be mentioned, e.g.: the number of deaths, the number of deaths from different causes, the shares of deaths from different causes among all deaths, as well as crude mortality rates (general and cause specific), they all depend very strongly on the age structure of the population. Age adjusted mortality rates (general and cause specific) are weighed averages of age specific mortality rates {in age class $[x, x + \Delta x)$} multiplied by fixed age structure coefficients, so they have all the advantages but also all the drawbacks of that kind of measures; in fact, the same value of age adjusted mortality rates can describe completely different mortality situations. The above mentioned measures do not give information about life potential of a population, and life potential loss due to alcohol abuse for instance, or any other considered cause of death.

Another problem, apart from the measurement, is the identification of the factors influencing the level of population mortality, including cause specific mortality, e.g. caused by alcohol abuse. Heavy drinking, binge drinking, especially when combined with unsuitable diet, are among the obvious causes of excessive mortality of alcohol abusers.

1. Proposed measure

Let us consider some of the mortality characteristics of the population of Poland according to gender and age. Figure 1 presents numbers of deaths in five-year gender/age classes in Poland in 2001.
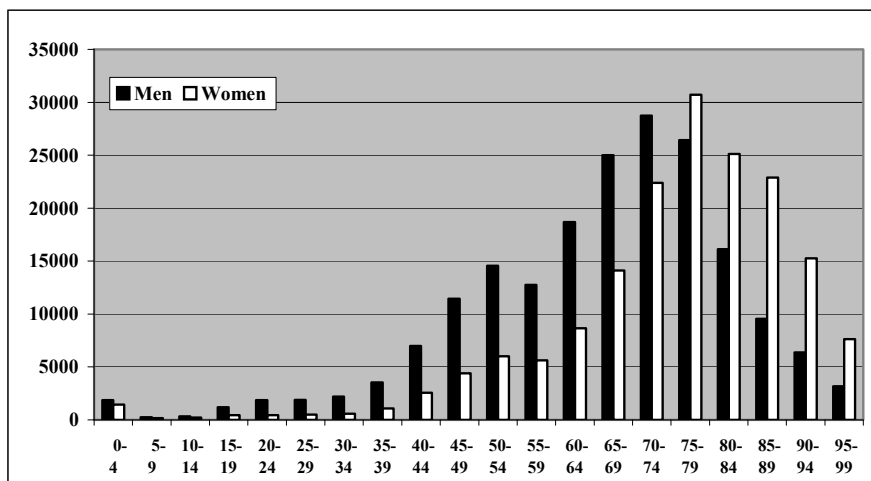

Figure 1. Number of deaths according to gender and age in Poland in 2001
Source: Author's own graph[1] on the basis of Demographic Yearbook of Poland 2002.

It can be observed that mortality status of women population in Poland can be described as much more advantageous than that of men[2] – relatively far fewer women than men die at young age, so the burden of mortality in the population of women is moved to the higher age classes.

As the number of deaths in every age class $[x, x + \Delta x)$ depends on the age structure of the population, theoretical numbers of deaths were also estimated – i.e. the numbers of deaths in every gender/age class, given the fixed coefficients of age structure in both populations considered. The results are presented in fig. 2. There are obvious differences among the numbers of deaths in particular gender/age classes in comparison with the ones presented in fig. 1, but the conclusion is much the same as the previous one – women in Poland are in a much more advantageous situation with regard to mortality than men.

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[1] For the purpose of graphical presentation (figures 1 and 2) the number of deaths in the last class of age [85 and over) was divided into three 5-year classes, assuming linear changes of number of deaths in this class.
[2] For explanation of these differences see, for instance, [2], p.182-192.
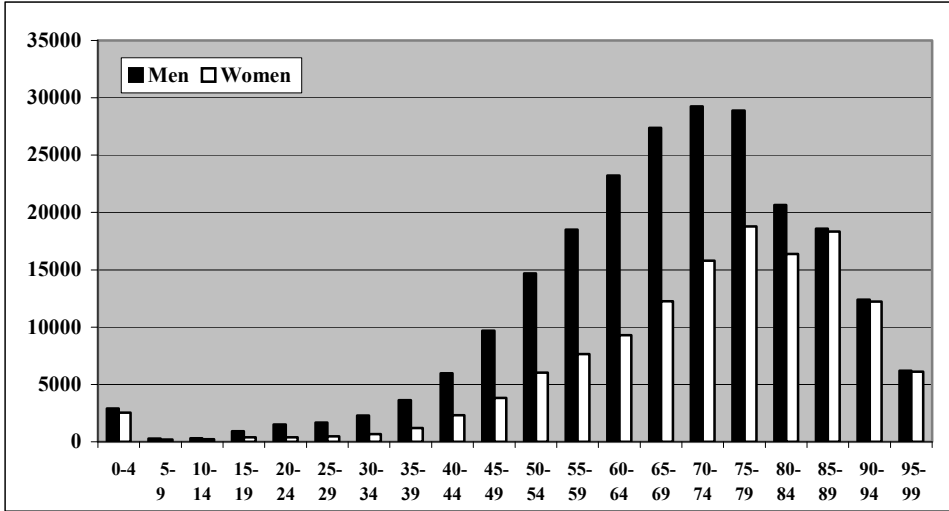
Figure 2. Expected number of deaths (fixed age structure) according to gender and age in
Poland in 2001
Source: Author's own graph on the basis of Demographic Yearbooks of Poland 2001-2.

A similar conclusion can be drawn on the basis of analysis of age specific general mortality rates for both populations (fig. 3).
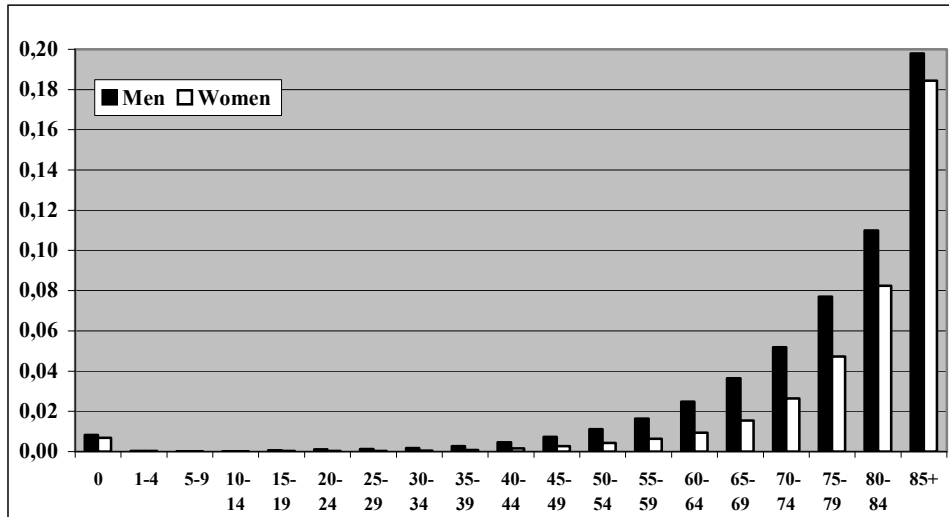

Figure 3. Age specific mortality rates according to gender in Poland in 2001
Source: Author's own graph on the basis of Demographic Yearbooks of Poland 2001-2.

The differences in mortality between men and women populations in Poland can be clearly seen; however the problem arises when one would like to measure them and characterise the mortality level of a population in a possibly concise way so as to make comparisons among different populations possible.

As it can be easily observed (fig. 1 and 2) – from a formal, statistical point of view, the two distributions (that is the distributions of the number of deaths according to age in men and women populations) differ according to skewness, so the author's proposition[3] was to base the possible measure of mortality level of a population on the measure of skewness of distribution. The relation could be described as follows: the worse the population's condition with regard to mortality is (in such population young people die more often), the more positively skewed the distribution of the number of deaths according to age in this population would be, and the burden of mortality would lie in high degree in the lower age classes, and conversely – the better the population's condition with regard to mortality is (in the population young people die less often), the more negatively skewed the distribution of the number of deaths according to age would be, so the burden of mortality would be shifted to higher age classes[4].

The proposed characteristic of this phenomena is formulated, in general, as follows:

$$V_p = \frac{A_{\max} + A}{2A_{\max}} \cdot 100 \qquad (1)$$

where

V_p – the proposed coefficient,

A – a skewness measure of the distribution of number of deaths according to age,
$A_{\max}$ – the maximum value of the applied skewness measure.

Coefficient V_p is equal to zero if the distribution of number of deaths in the population is possibly the most advantageous one, and 100% – if it is the worst one.

When as a measure of skewness the third standardized moment $\left\{ A_3 = \frac{M_3}{[D(X)]^3} \right\}$ is applied[5], formulae (1) could be re-written in the following form:

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[3] The author presented the proposed measure V_p during the XL Conference of Statisticians, Econometricians and Mathematicians of the South Poland in Podlesice (2004).

[4] Theoretically the best situation would be if everybody would die in the highest age class.

[5] Where $M_3 = E[X - E(X)]^3$, and $D^2(X) = E[X - E(X)]^2$. It is often assumed for practical purposes that the values of the coefficient A_3 belong to interval *(-2, 2)*.

$$V_p = \frac{2 + A_3}{4} \cdot 100 = (2 + A_3) \cdot 25 \tag{2}$$

The distributions of age specific mortality rates in both considered populations are J-shaped (extremely negatively skewed), so to characterize in a synthetic way these distributions instead of skewness measures rather a concentration measure (for instance Gini coefficient of inequality C_G) should be applied; the values of Gini coefficient could be in this case interpreted as follows: the more advantageous the population's condition with regard to mortality, the higher value of Gini coefficient would be observed, and conversely[6].

Finally, as for instance from the point of view of economic and social possibilities of a country's development it makes a difference whether a young or an old person dies, as a characteristic of mortality of a population the life potential of the population[7] could be evaluated, as follows:

$$V[w,W;t,T] = \sum_{w}^{W-1} P_x \cdot V_x[t,T] \tag{3}$$

where

$V[w,W;t,T]$ – denotes life potential of people at the age w to W in the interval t to T years of their lives[8],

P_x – number of people at the age x finished years of life,

$V_x[t,T]$ – life potential of people at the age x finished years of life, which can be calculated

as follows:

$$V_x[t,T] = \frac{l_t \cdot e_t - l_T \cdot e_T}{0,5 \cdot (l_x + l_{x+1})} \tag{4}$$

where

l_t, l_T, l_x, l_{x+1} – number of people, who will live up to the year $t,T,x,x+1$,

e_t, e_T – life expectancy of people at the age t or T.

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[6] Assuming there are no high age specific mortality rates in lower age classes (e.g. infant mortality); it is suggested to present the considered distribution on a graph.

[7] Life potential measures (formulas (3) and (4)) were proposed by L. Hersch [4], here quoted after [9], p. 39-40.

[8] w, W – denotes here age (in years), while x – number of finished years of life.

Life potential of a population is here understood as a number of years the whole population is expected to live.

In the author's opinion to estimate the range of alcohol abuse (or any other cause of death) influence on mortality, the deaths from the considered cause should be theoretically eliminated. It also should be stated, how this theoretical change would influence the values of mortality characteristics; among others the above presented measures defined by formulas (1), (2), (3) could also be applied for the purpose. Hence, in the case of this study, the number of deaths caused by alcohol abuse in Poland in 2001 should be estimated, and then – theoretically – eliminated.

It has been often observed (e.g. [6], p. 436) that the number of deaths officially registered as the deaths related to alcohol abuse is too low. The reasons could be for instance: the doctor who drew up the death certificate might not have known that the person was an alcohol abuser, or even if he had been aware of the fact, it could have been very difficult (or simply not possible) to state the degree of alcohol contribution to the death. Not without meaning is justifiable tendency of the family of the deceased to avoid mentioning alcohol as the cause of death. Therefore the theoretical elimination of the number of deaths caused by alcohol abuse was in the presented study conducted in an indirect way – standardized mortality ratios γ_i, that is the ratios of the observed to expected numbers of deaths of alcoholics in gender/age class *i,* were applied in the formula suggested previously (on the basis of W.F. Forbes and M.E. Thompson's proposition [5]) by the author[9]:

$$m_{ni} = \frac{m_i}{1 + (\gamma_i - 1) \cdot p_i}$$ (5)

where

m_{ni} – general mortality rates estimated on assumption that there were no deaths
    caused by alcohol abuse in the population in age class *i,*
m_i – general mortality rates observed in the population in age class *i,*
p_i – share of alcoholics in age class *i,*
γ_i – standardized mortality ratio, that is the ratio of the observed to expected
    number of deaths of alcoholics in that class,
i – age class $[x, x + \Delta x)$.

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[9] [7], p. 203.

Due to of the shortcomings of the statistical data it has been assumed that population consists exclusively of alcoholics and non-alcoholics; "alcoholics" were here understood as people, who had abused alcohol for a long time suffering in result from some health and social negative consequences. Coefficients γ_i, that is the ratios of the observed to expected number of deaths of alcoholics in an age class $[x, x + \Delta x)$, were estimated by the author on the basis of [1] and [3], while the shares of alcoholics p_i in every age class were evaluated on the basis of distribution of the numbers of deaths on acute alcohol poisoning in Poland[10] in 2000, and estimated number of alcoholics in Poland in 2001. To estimate the number of alcoholics Jellinek estimation formula[11] was used (authors own estimates [7] of share of the liver cirrhosis deaths related to alcohol abuse in Poland were applied).

Combining the use of the Jellinek's formula for estimation of the size of population of alcoholics in Poland in 2001 with the estimated on the basis of [1] and [3] coefficients, γ_i creates the problem of comparability of the definitions of "an alcoholic" applied in both studies. While the results of the estimation of standardized mortality ratios concern clinically treated alcoholics, in the Jellinek's study the class of alcoholics was understood in much broader sense; in contemporary terminology they would be called "alcohol abusers"[12] rather than "alcoholics", while Jellinek's population of "alcoholics with complications" corresponds roughly to the contemporary definition of the population of alcoholics. In that context the applied coefficients γ_i correspond to the Jellinek's population of "alcoholics with complications" rather than to his population of "alcoholics".

On the other hand – while it is not necessary to be a clinically treated alcoholic to die in the result of a traffic (or other) accident occurred under influence of alcohol, or to commit suicide under such influence – mortality among population of alcoholics in broader sense is certainly also higher than in the general population; the problem is that the values of standardized mortality ratios for population of alcoholics defined in such a way have not been estimated yet. As, in this study, the class of "alcoholics" was broadly understood, the results of the estimation presented below should be treated as the upper limits of the range of possible negative influence of alcohol abuse on mortality in Poland in 2001.

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[10] Data of Central Statistical Office in Warsaw.

[11] [8]. The method is also in detail described in [7].

[12] According to the Report on the First Session of the Alcoholism Subcommittee of Expert Committee on Mental Health [WHO, Geneva 1951], where E.M. Jellinek presented his formula, the term "alcoholism" the subcommittee used "[…] to signify any form of drinking which in its extent goes beyond the traditional and customary "dietary" use […]" [8], p. 5.

2. Results

Table 1 presents the results of applying of the proposed coefficient V_p to empirical crude and age adjusted distributions of number of deaths, and than to adequate theoretical distributions estimated, given there were no deaths caused by alcohol abuse.

Table 1

Coefficient of skewness (A_3) and coefficient V_p applied to empirical and theoretical crude and age adjusted distributions of number of deaths according to age in Poland in 2001

Research profile	Skewness (A_3)		Coefficient V_p (in %)	
	Men	Women	Men	Women
Empirical	- 0.9111	- 1.5460	27.22	11.35
Empirical, age adjusted	- 0.9804	- 1.4744	25.49	13.14
Theoretical	- 1.2438	- 1.7936	18.91	5.16
Theoretical, age adjusted	- 1.2739	- 1.7359	18.15	6.60

Source: Author's own calculation on the basis of Demographic Yearbooks of Poland 2001-2.

It can be stated that elimination of deaths caused by alcohol abuse in Poland in 2001 would improve the condition of the population of men with regard to mortality by about 8.31% (or by about 7.34% for fixed age structure) which could be interpreted as follows: the distribution of number of deaths according to age in population of men would be by about 8.31% (or by about 7.34%) more advantageous (that is shifted towards negative skewness) – given, there were no deaths caused by alcohol abuse – than in the existing population. In case of

women the adequate possible improvement would vary from about 6.19% to about 6.54% (fixed age structure).

Similar conclusion could be drawn on the basis of analysis of estimates of Gini coefficients (C_G) of concentration of number of deaths calculated on the basis of age specific mortality rates in both considered populations.

Table 2

Estimated values of Gini coefficient (C_G) of concentration of number of deaths calculated on the basis of age specific mortality rates in Poland in 2001

Research profile	Gini coefficient (C_G)	
	Men	Women
Empirical	0.7442	0.8074
Theoretical	0.7826	0.8314

Source: Author's own calculation on the basis of Demographic Yearbooks of Poland 2001-2.

It could be observed, that the concentration of the number of deaths (calculated on the basis of age specific mortality rates) in the populations of men and women would be higher, assuming there were no deaths caused by alcohol abuse – which means in this case that mortality at the young age would be lower and mortality at the old age would be higher than in both empirical populations, so the burden of mortality would be shifted to higher classes of age; the condition of the population with regard to mortality would be in that way improved.

Finally, the possible gain (given there were no deaths caused by alcohol abuse) of life potential (formula (3)) of both populations was estimated: if there were no deaths caused by alcohol abuse, life potential of the population of men in Poland in 2001 would be by about 2.16% (that is by 10 305 251 person-years) higher, and life potential of the population of women would be by 1.27% (that is by 7 874 602 person-years) higher than the life potential of the real populations. The results of the above estimation are illustrated by fig. 4 and 5.
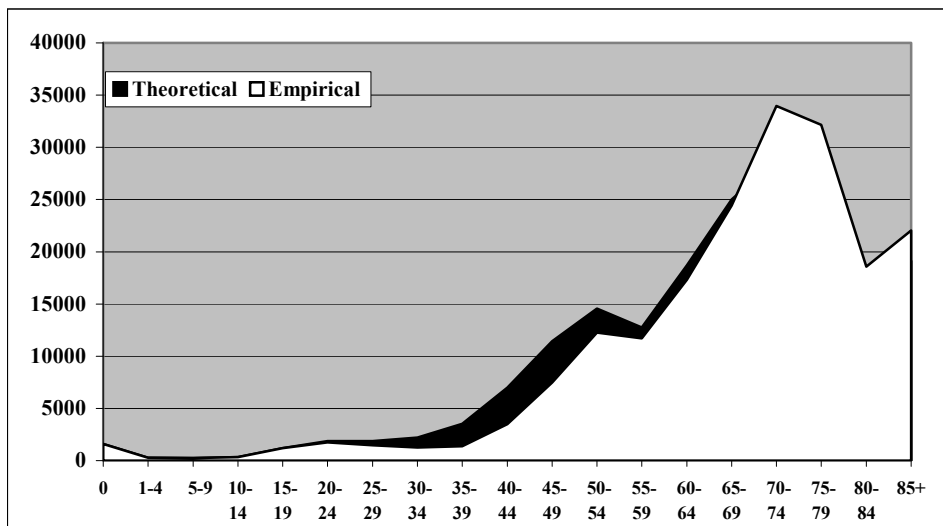
Figure 4. Empirical and theoretical life potential of men in Poland in 2001
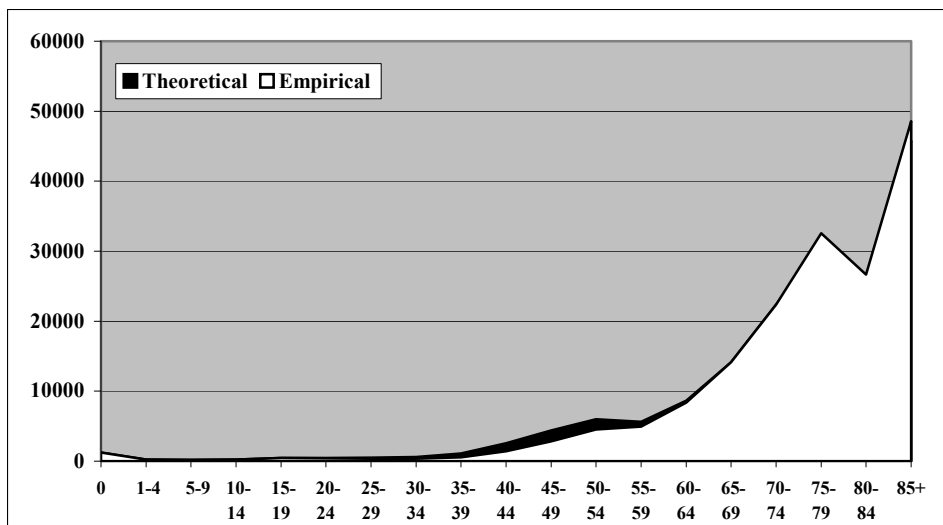Source: Author's own graph on the basis of Demographic Yearbooks of Poland 2001-2.

Figure 5. Empirical and theoretical life potential of women in Poland in 2001
Source: Author's own graph on the basis of Demographic Yearbooks of Poland 2001-2.

Additionally, life expectancy[13] for newborns (e_0), empirical and theoretical, given there were no deaths due to alcohol abuse, were estimated (table 3).

Table 3

Estimated values of life expectancy for newborns (e_0) in Poland in 2001

Research profile	Life expectancy for newborns (e_0)	
	Men	Women
Empirical	69.85	78.12
Theoretical	70.92	78.77

Source: Author's own calculation on the basis of Demographic Yearbooks of Poland 2001-2.

Estimated life expectancy gain $\Delta e_{0.\lambda} = e_{0.\lambda} - e_0$, where $e_{0.\lambda}$ denotes theoretical (assuming there were no deaths caused by alcohol abuse) life expectancy for newborns, would be equal to 1.07 year for men and to 0.65 of a year for women.

Conclusions

The following conclusions can be drawn from the research:

1. It can be observed that alcohol abuse negatively influences the values of mortality characteristics of the population of Poland. As in Poland men drink much more alcohol than women, the influence is much better visible in the population of men – if there were no deaths caused by alcohol abuse in Poland in 2001, the distribution of number of deaths according to age in population of men would be by about 8.31%, and in the case of women by about 6.19% more advantageous than in the empirical populations; life potential of men would be by about 2.16% higher, and that of women by 1.27% higher than life potential of populations existing in 2001 in Poland, and estimated life expectancy gain would be equal to 1.07 year for men and to 0.65 of a year for women.

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[13] Estimation was performed with the use of computer program of University of Economics in Wroclaw "Ludzik".

2. To estimate the range of influence of alcohol abuse (or any other cause of deaths) on mortality, the real empirical situation should be, in the author's opinion, compared to the theoretical one – assuming that the considered cause of death is eliminated.

3. The use of proposed for that purpose coefficient V_p – together with other applied measures – makes the estimation possible, as well as the comparisons of the range of influence of the chosen cause of death on population mortality among different populations (or relevantly among different causes of death), so it can be regarded as one of the possible measures of burden of mortality attributable to alcohol abuse.

References

Adelstein A., White G.: Alcoholism and Mortality. "Population Trends" 1976, No. 6.

Bijak J.: Umieralność. In: Przemiany demograficzne w Polsce w latach 90. w świetle koncepcji drugiego przejścia demograficznego. Ed. I. Kotowska. Szkoła Główna Handlowa, Warszawa 1999.

Brodniak W., Moskalewicz J., Rabczenko D., Wojtyniak B.: Mortality among Treated Alcoholics in Poland, paper presented at the 28th Annual Alcohol Epidemiology Symposium, Paris, 3-7 June 2002.

Hersch L.: Demographie potentielle et vieillissement de la population. "Population" 1948, No. 2.

Forbes W.F., Thompson M.E.: Estimating the Health Care Costs of Smokers. "Canadian Journal of Public Health" 1983, No. 74.

McDonnell R., Maynard A.: The Costs of Alcohol Misuse. "British Journal of Addiction" 1985, No. 1.

Mielecka-Kubień Z.: Ilościowe aspekty badania problemów alkoholowych w Polsce (Quantitative Aspects of Research on Alcohol Problems in Poland). AE, Katowice 2001.

Report on the First Session of the Alcoholism Subcommittee. Annex 2. Expert Committee on Mental Health, World Health Organization, Geneva 1951.

Vielrose E.: Zarys demografii potencjalnej. PWN, Warszawa 1958.