Potential years of life lost

The PYLL rate in monitoring the wellbeing of a population

Ilkka Vohlonen, Heli Bäckmand, Jari Korhonen

Background
The potential years of life lost (PYLL) rate describes the number of potential years of life lost due to premature death in a population. From a social point of view, this is equal to loss of human capital.
Methods
The rate is calculated on the basis of the difference between the age at death and the expected length of life, and it is determined by the cause of death according to the ICD-10. The method reviews the time of death in relation to pre-defined life expectancy. The rate is age-standardized and expressed as a sum of all deaths per 100,000 person- years.
Results
There were differences in the PYLL rates of all causes of death in the OECD countries compared. The differences between regions in Canada and Finland were as large as the differences between the selected OECD countries. Although the population of a Finnish municipality is often small, the PYLL rates mainly turned out to be statistically reliable according to the 95 % confidence intervals for all causes of death.
Conclusions
The PYLL rate provides comparable information about the wellbeing of a population concerning all death causes. It provides supplementary information for planning and decision-making for health policies.

This was a familiar issue

- The potential years of life lost rate is one of the most used indicators for the wellbeing of the population. It is used, for example, by the World Bank, OECD, WHO and EU when evaluating the development of the wellbeing of population in different countries.
- The differences in wellbeing between countries and regions are affected by various different factors: genes, living habits and environment, catastrophes, health policies in a country or region, various functions of different sectors of the society and practiced social and health policies.
- *What was learned from this research?*
- The potential years of life lost rate offers the possibility to compare, monitor and evaluate the wellbeing of population internationally between municipalities, sub-regions, regions and countries.
- The PYLL rate produces comparable information to support strategic planning and decision-making on both country and municipality level. Results may change due to conclusions made on the basis of a population that is too small and differences in procedures in writing death certificates.

Internationally, different parameters describing mortality are used as indicators of health and measures for wellbeing (1,2) of a population or its part. In total mortality, all death causes of the population are taken into account. Death due to different illnesses can be reviewed by disease-based death rates. The potential years of life lost rate is used for reviewing the time of death in relation to life expectancy (1,3) set for different causes of death. What is new compared to earlier research studying mortality is that the PYLL rate takes into account not only the number of the dead but also the age of each deceased individual at the time of death. The PYLL rate is one of the most used wellbeing parameters in the world. It is used, for example, by the World Bank, OECD, WHO and EU when evaluating the wellbeing development of the population in different countries. In Canada, potential years of life lost have been monitored for 30 years yearly in provinces, territories and counties. In Finland, potential years of life lost have not been monitored with this international method before the year 2003 by municipality, sub-region or health care region (4). So far, almost half of the municipalities have been analyzed.

In international comparison, or when describing development in a long period of time, mortality can often provide more reliable information with better coverage than other indicators describing the population's living conditions and health. Mortality rates are usually counted by age groups with five-year age ranges. The total mortality rate of the population is thus the weighed average of the mortality of different age groups. Mortality rates are used as a basis also when counting the average expected life years of the population. Internationally, the mortality statistics can be considered among the most comparable, although the procedures of registering and classifying mortality rates differ in different countries.

The PYLL rate is very sensitive for indicating death at early years. For instance, one individual who has died at the age of 40 will give the rate the same numerical value as ten individuals died at 76.

Originally the Potential years of life lost rate was used in epidemiology, but later it has been used as a method in national economy. By combining information acquired from the PYLL-rate with information provided by other indicators, the results of health policies, wellbeing strategy or other previous measures in national economy can be reviewed. With monitoring the potential years of life lost in a long period of time, conclusions can be made on whether the wellbeing of a population is developing into a good or a bad direction. The loss of wellbeing in total social costs can be counted on certain diseases (such as cardiovascular diseases and diabetes, alcohol-related diseases, cancers, suicides, accidents and poisonings) by proportioning the potential years of life lost to the per capita yearly gross national product. The indicator offers a possibility to set the necessary measures in promoting wellbeing in order of importance.

The aim of our research was to describe the premature loss of mental capital of the population measured by the potential years of life lost rate in different countries, and to compare the situation in Canada and Finland, in Finnish towns and municipalities and regionally by sub-regions concerning all causes of death.

Data and methods

In the data, the rate calculation is based on the basic cause of death in the statistics on causes of death, classified since 1998 using the international classification of diseases by the World Health Organization, ICD-10 (5). Basic causes of death have been classified in 28 classes in the research data. Before the ICD-10 classification, several previous versions of disease classification have been used, so in order to make available registered information comparable, certain causes of death had to be relocated between these preventable 28 classes (6). The cause of death classification has been made on the basis of time series classification used in the statistics on causes of death. Time series classification could not be used in cause of death classes 6, 10, 11, 16, 22, but they have been formed separately using the ICD-codes of each time in question. Table 1 presents the causes of death used.

For comparing different countries in the research, the data used was country-based information on potential years of life lost published by the OECD (1). For comparing the situation in Finland and Canada, we used data of potential years of life lost provided by the Statistics Finland and Statistics Canada.

Calculating the potential years of life lost rate

A potential year of life lost means that an individual dies younger than what his/her life expectancy is. The calculation of the PYLL rate is based on the following pattern (3, 7):

Basic Formula

$$PYLL_{i\,t} = \Sigma\,(l - a)(d_{at}/p_{at})(p_a/p_n) * 100\,000$$

In the pattern, *l* represents the population's life expectancy, which is 70 years; d_{at} is the number of deaths in a certain age group in each municipality (*i*) during each year (*t*), p_{at} is the number of population in an age group in a certain municipality. P_a is the number of standard population in a certain age group (OECD 1980) and P_n is the total of standard population (0-69 years of age). The municipality-based potential years of life lost rate is calculated according to the tax municipality of the deceased, regardless of the place of death.

Age grouping is done by division in five-year groups as in OECD countries, so that those under the age of one and those from 1-4 form their own classes. Potential years of life lost are calculated in OECD as a one-year sum and in Canada as a three-year total per 100,000 person years (8). Because the populations of municipalities are small, potential years of life lost in Finland are calculated using a five-year cumulative monitoring period. These were calculated from three different periods (e.g. 1983–87, 1991–95, 2000–04) proportioned to 100,000 person years. When the yearly cause- of-death statistics are final, the five-year periods are always counted with the latest figures. The rate is age-standardized using the direct method (7). In order to clarify the statistical reliability of trends for each municipality in the period of 20 years, a 95 % confidence interval was calculated for the PYLL rate for each municipality. The difference between calculating the confidence intervals of PYLL rates and only mortality rates is that in the before-mentioned, the potentional years of life lost must

be taken into account for each deceased individual. In practice, the weights for each potential year of life lost and each death are the same.

The calculation of the PYLL rate variance is based on the following pattern (7, 9):

Variance formula
VAR of PYLL = Σ (C*2 x N x P x Q)

and based on this, the confidence intervals are calculated as follows:

Confidence interval formula
95 % conf int of PYLL= (PYLL) +/- (1.96 x √ (variance (PYLL))

In the PYLL rate variance calculation pattern, C represents the potentional years of life lost/death (In Finland, the middle of the 70-year age group), N represents the age group's person-years in the monitoring period, P is the mortality rate of the age group in the monitoring period (age group deaths/N), and Q is 1-P. The pattern will be calculated by age groups and the results will be added together.

Results

International comparison on all causes of death shows that there are big differences between countries in prematurely lost life years. Out of the selected OECD countries, the best wellbeing is found in Sweden and the poorest in the United States (**figure 1**). Because Russia is not an OECD country, its PYLL rates have not been published. During the years 1998 –2000, calculations made in Russia (the TACIS project) showed that the PYLL rates for Russians were as large (12,000 – 18,000) as those of the Canadian aboriginal populations (Indians and Inuites). The wellbeing development has improved in the last ten years (**figure 2**). In the beginning of the monitoring period, the wellbeing situation in Canada was better than in Finland. Now the wellbeing of the population of Canada measured with this indicator is only slightly better than that of Finland. When comparing Canada's (10) British Columbia province and Finland's demographically similarized areas, it appeared that in both countries, the differences between municipalities within the PYLL rates were as big as the differences between countries presented in our comparison (table 2). Although the PYLL rate for the whole population of Canada was slightly better than the corresponding figure for the Finnish population (figures 1 and 2), due to the selection of towns and the time difference of available Canadian data for each town compared to the Finnish data, the PYLL rates for the populations of the selected Canadian towns were poorer than those of the corresponding Finnish populations (table 2).

In our country, the PYLL rates per municipality vary a lot both between big towns (**figure 3**) and smaller localities (**figure 4**) and in provinces between different sub-regions (**figure 5**). The sample results show that the situation of wellbeing in some municipalities has developed propitiously, whereas in others, the development has been the opposite. Different development between localities shows, for example, that a change in social structure and development affect different municipalities and areas in different ways, despite the fact that removing regional differences has been a central principle in social policy.

Even though in some cases, due to the small population of a municipality, the cause of death statistics are statistically unreliable based on a 95 % confidence interval, it has in practice turned out that in any case, it is possible to interpret causes of premature death. Because only half of our country's municipalities have been analyzed and no systematical research analyzing the reasons for differences between municipalities has thus been initiated, no specific municipality-based results are presented herein.

Discussion

The development of the population's wellbeing has traditionally been studied using mortality statistics. Cause-of-death data has been acquired from the statistics on causes of death. The classification of causes of death has changed from1987 ICD-8 to Disease classification 1987 and 1996 ICD-10. There have also been changes in municipality classification. Due to the consolidation of municipalities, the monitoring of individual municipalities can not be considered consistent without knowing the structure of population of each municipality and how it develops during the monitoring period.

Internationally, the mortality statistics can be considered among the most comparable ones, although the procedures of registering and classifying causes of death differ in different countries. The reliability of cause-of-death data depends on the information available for the physician in writing the death certificate, whether the death certificate form is filled correctly, and how correct the basic cause of death classification of the statistic is and what coding procedures prevail. Special attention must be paid to diabetes-originated deaths, which are mainly caused by vascular events. This is why it is important to further develop reporting in different diagnosis groups to better support decision-making.

The measuring method uses life expectancy in OECD countries (OECD countries 70 years, Canada 75 years). The method does not take into account exceeding the set life expectancy. The small size of our municipalities causes statistical restrictions to the generalization of the parameters. The PYLL rates on all death causes per municipality have appeared to be mainly reliable both statistically and qualitatively, when using cumulative monitoring time and when calculating 95 % confidence intervals for acquired rates. In addition, it is necessary to combine both the amounts of the deceased and the potential years of life lost for each deceased individual. The fact that the 95 % confidence intervals for the PYLL rates are smaller in Canadian localities than in our country can be caused by two factors: Either it is because the life expectancy value for Canadian population is set to a higher value, or because the age of the Finnish deceased is clearly lower than that of the Canadians.

On premature deaths, it has become clear that in some of the municipalities defined by the rate as having a poor situation, men died approximately five years earlier than in good situation municipalities, and in poor situation municipalities, women died as many as ten years earlier than in the good situation municipalities. When over 200 municipalities or towns have been analyzed and the results have been gone through with local experts and elected officials, it has occurred that in many municipalities, correcting the poor PYLL rates mainly requires measures outside health care. In some municipalities, increasing social and health care costs would probably not help

reduce premature deaths remarkably. It has also occurred, that instead of traditional life-style related risks (smoking and nutritional factors) modern phenomena like loneliness and alcohol abuse cause premature deaths increasingly. Poorly working health care can seldom be proved to be the only reason for a large number of premature deaths. It still seems to be much more common that in some areas patients do not seek treatment or follow treatment instructions well enough.

TABLE 1
Diagnostic groups used in the Potential years of life lost (PYLL) rate.

	Diagnostic groups	Classification of diseases
1.	All causes of death	A00–R99, V01-Y89
2.	Infectious & parasitic diseases	A00–B99, J65
3.	Human Immunodeficiency Virus (HIV) disease	B20–B24
4.	Malignant neoplasms	C00–C97
5.	Malignant neoplasms of colon, rectum, rectosigmoid junction and anus	C18–C21
6.	Malignant neoplasm of trachea, bronchus, lung	C33–C34
7.	Malignant neoplasm of the female breast	C50
8.	Endocrine, nutritional and metabolic diseases and immunity disorders	E00–E90
9.	Diabetes mellitus	E10–E14
10.	Diseases of blood & blood forming organs	D50–D89
11.	Mental and behavioral disorders	F00, F02, F04–F09, F11–F99
12.	Dementia, Alzheimer's disease	F01, F03, G30, R54
13.	Diseases of nervous system and sense organs	G00–G29, G31.0–G31.1, G31.8–G62.0, G62.2–G72.0, G72.2–H95
14.	Diseases of circulatory system	I00–I42.5, I42.7–I99
15.	Ischaemic heart disease	I20–I25
16.	Acute myocardial infarction, subsequent myocardial infarction	I21, I22
17.	Cerebrovascular diseases	I60–I69
18.	Diseases of respiratory system	J00–J64, J66–J99
19.	Influenza and pneumonia	J10–J18, J84.9
20.	Bronchitis, asthma and emphysema	J40–J47
21.	Diseases of the digestive system	K00–K29.1, K29.3–K67,K71–K85, K86.1–K93
22.	Chronic liver disease and cirrhosis	K73, K74, K76
23.	Alcohol-related diseases and alcoholic myopathy	F10. G31.2, G40.51, G62.1
24.	External causes of injury and poisoning	V01–X44, X46–Y89[1]
25.	Motor vehicle accidents	V01–X44, X46–Y89[1]
26.	Other transport accidents	V01–X44, X46–Y89[1]
27.	Accidental falls	W00–W19
28.	Suicide and self-inflicted injury	X60–X84, Y87.0

[1]See causes of death publication appendix 2B (6).

Fig. 1

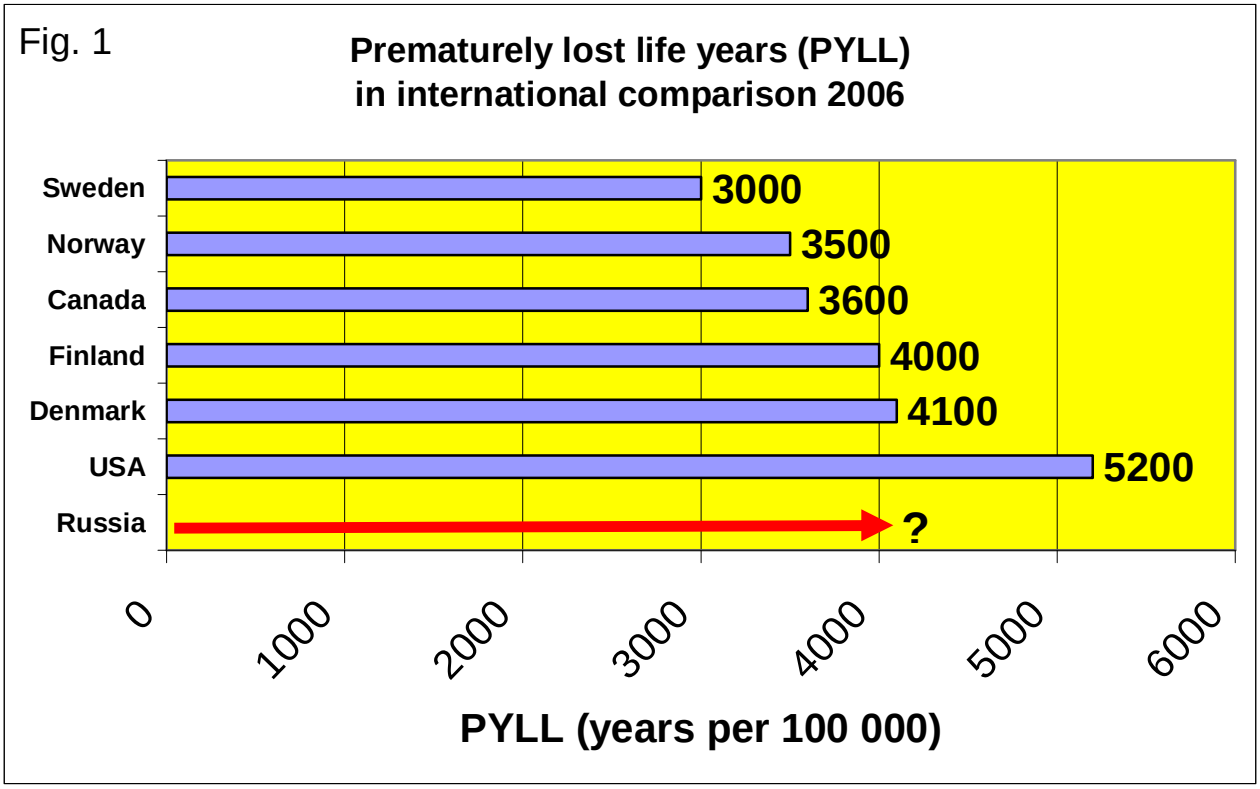

Prematurely lost life years (PYLL)
in international comparison 2006
Sweden
Norway
Canada
Finland
Denmark
USA
Russia
3000
3500
3600
4000
4100
5200
?
0
1000
2000
3000
4000
5000
6000
PYLL (years per 100 000)

Fig. 2

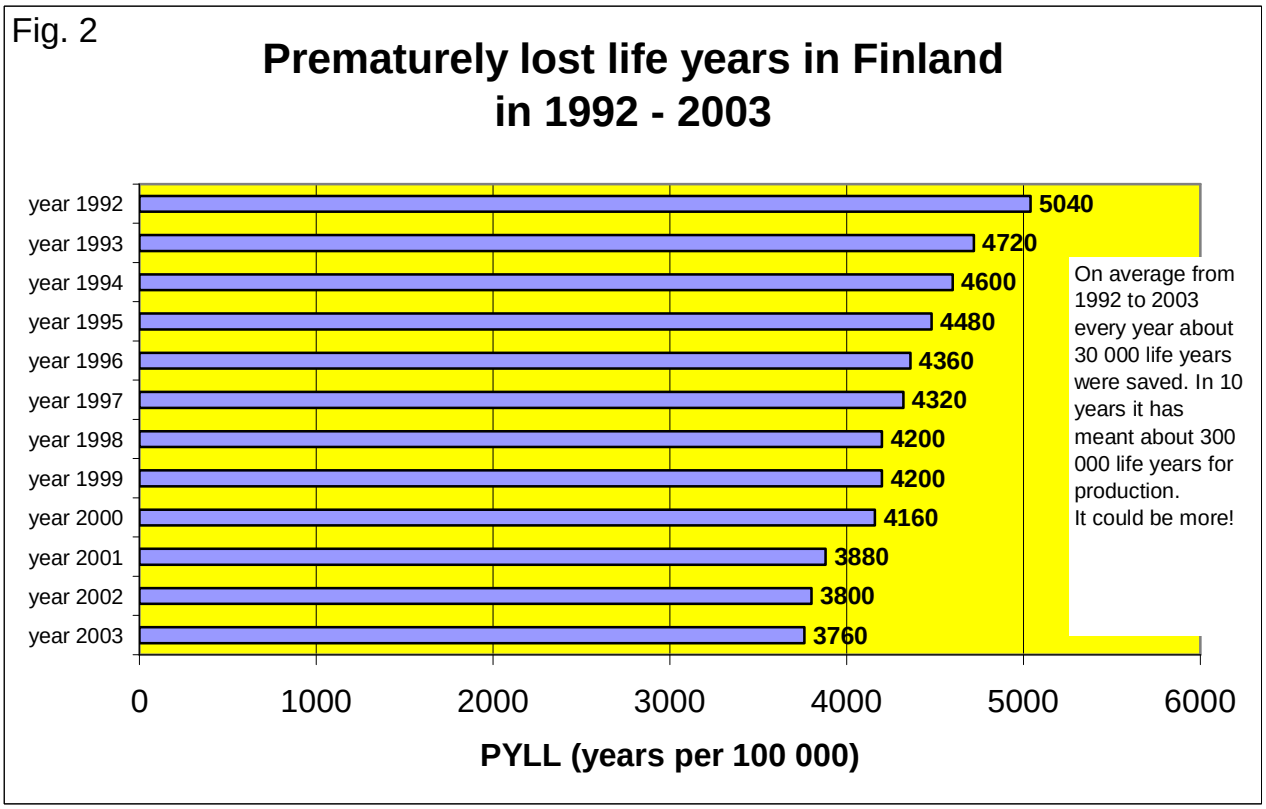

Prematurely lost life years in Finland
in 1992 - 2003
year 1992
year 1993
year 1994
year 1995
year 1996
year 1997
year 1998
year 1999
year 2000
year 2001
year 2002
year 2003
5040
4720
4600
4480
4360
4320
4200
4200
4160
3880
3800
3760
On average from 1992 to 2003 every year about 30 000 life years were saved. In 10 years it has meant about 300 000 life years for production.
It could be more!
0
1000
2000
3000
4000
5000
6000
PYLL (years per 100 000)

Fig. 3.
Prematurely lost life years in 4 cities in Finland in 1983 - 2004. All causes of death.

Kuvio 3.

Menetetyt elinvuodet, kun otetaan huomioon kaikki kuolinsyyt (A00–R99, V01–Y89) neljässä Suomen kaupungissa vuosina 1983–2004, 95 %:n luottamusväleineen.

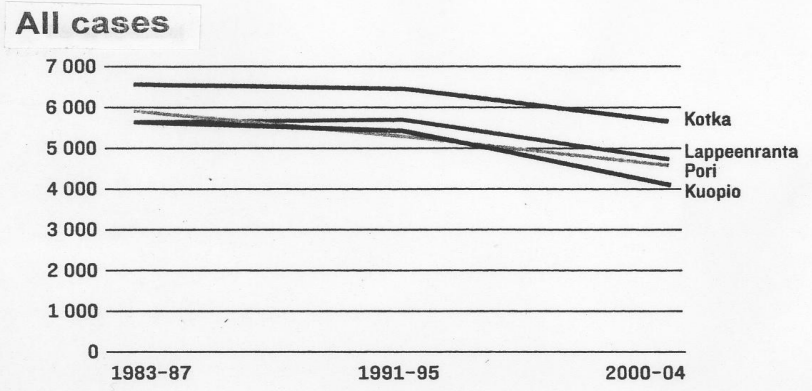


Fig. 4.
Prematurely lost life years in 4 municipalities in Finland in 1983 - 2004. All causes of death.

Kuvio 4.

Menetetyt elinvuodet, kun otetaan huomioon kaikki kuolinsyyt (A00–R99, V01–Y89) neljässä Suomen kunnassa vuosina 1983–2004, 95 %:n luottamusväleineen.

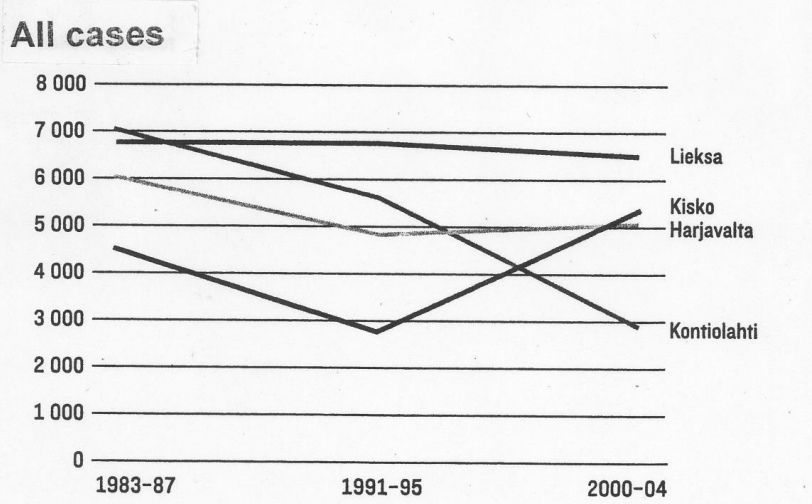


Fig. 5.
Prematurely lost life years in 3 regions in North-Karelia in 1983 - 2004. All causes of death.

Kuvio 5.

Menetetyt elinvuodet, kun otetaan huomioon kaikki kuolinsyyt (A00–R99, V01–Y89) Pohjois-Karjalan kolmessa seutukunnassa ja Pohjois-Karjalan maakunnassa vuosina 1983–2004, 95 %:n luottamusväleineen.

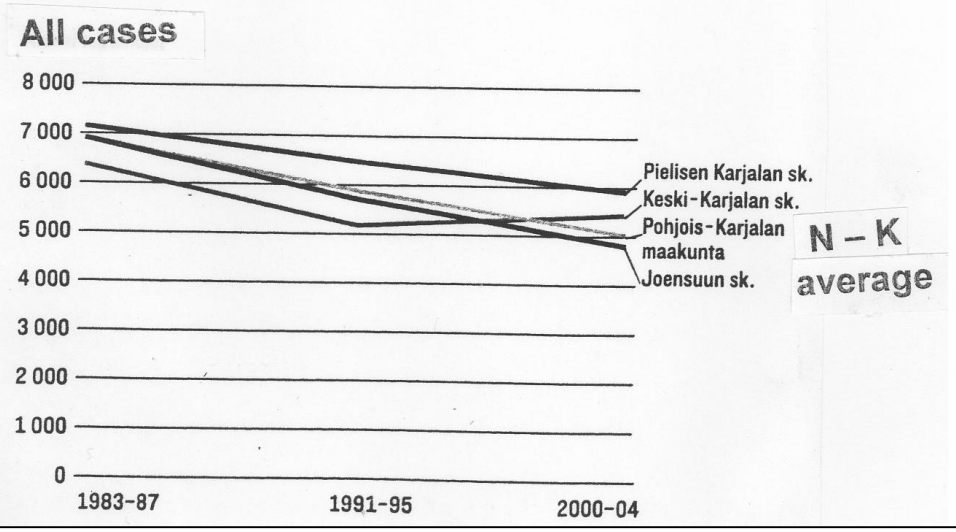
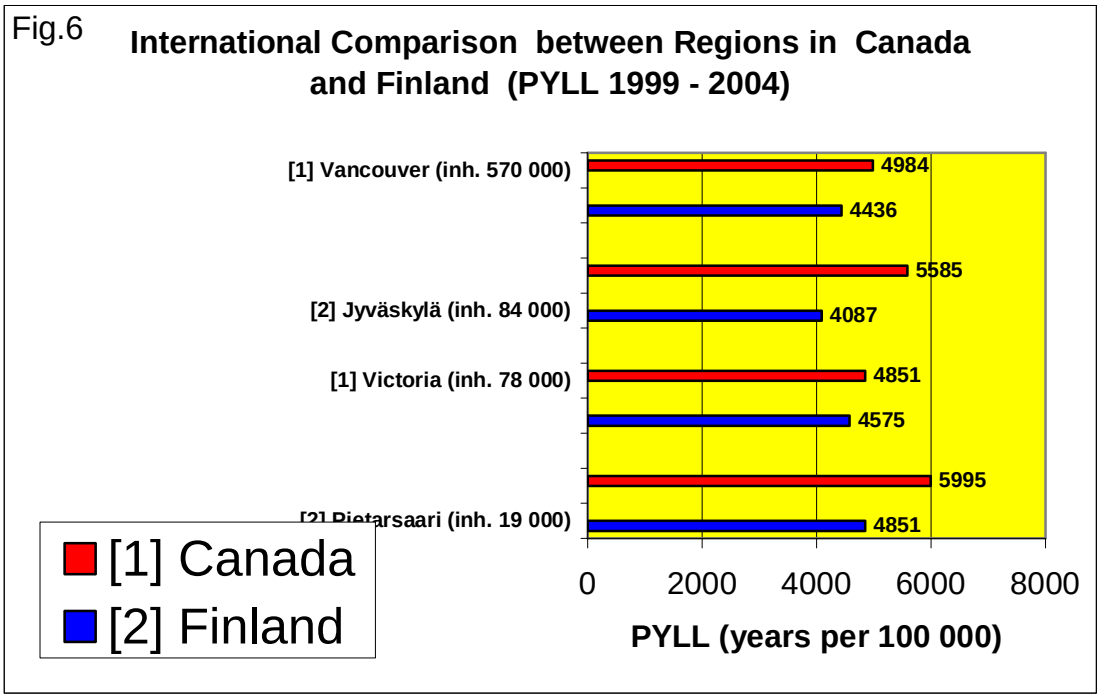


Table 2

Potential years of life lost, all causes of death (A00–R99, V01–Y89) in Canadian (during time period 1999–2001, 0–74-ages) and Finnish (during time period 2000–2004, 0–69-years of age) towns with 95 % confidentiality intervals.

Town	PYLL	95 % RR	Number of population
Helsinki1	4 436	3 704–5 168	559 046
Vancouver2	4 984	4 951–5 017	569 473
Jyväskylä1	4 087	3 360–4 814	83 582
Prince George2	5585	5 517–5 653	75568
Pori1	4575	3 832–5 318	76152
Victoria2	4851	4 808–4 895	77362
Pietarsaari1	3326	2 689–3 963	19467
Prince Ruper2	5995	5 901–6 089	15282

Fig.6



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Authors:

Ilkka Vohlonen, Ph.D. Professor, Leader of Research
University of Kuopio, Efeko Oy
ilkka.vohlonen@fcg.fi

Heli Bäckmand, FT, Development Manager
Efeko Oy

Jari Korhonen
M.D., Occupational Health Physician, Medical Administrator,
Provincial Medical Pfficer, State Provincial Office of Eastern Finland

SUMMARY
Potential years of life lost
PYLL-rate in monitoring the wellbeing of a population

Background
The potential years of life lost (PYLL) rate is one of the most frequently used measures for monitoring the health of a population. It describes the number of life years lost due to premature death. From a social point of view this is equal to loss of human capital.

Methods
The rate is calculated on the basis of the difference between the age at death and the expected length of life, and is determined by cause of death according to the ICD-10. The rate is age-standardized and expressed as a sum of all deaths per 100 000 person years.

Results
In the international comparison, there were differences between countries in each of the cause specific PYLL rates. Within the countries Canada and Finland, the differences between regions were as large as the differences between selected OECD countries. Although the population of a Finnish municipality is often small, the PYLL rates by and large turned out to be statistically reliable according to the 95 percent confidence intervals for total deaths.

Conclusions
The PYLL rate provides comparable information about the wellbeing of a population for planning and decision-making of health policies by diagnosis group and by region and municipality.

Authors:

Ilkka Vohlonen, Ph.D. Professor, Leader of Research
University of Kuopio, Efeko Oy
ilkka.vohlonen@fcg.fi

Heli Bäckmand, FT, Development Manager
Efeko Oy

Jari Korhonen
M.D., Occupational Health Physician, Medical Administrator,
Provincial Medical Pfficer, State Provincial Office of Eastern Finland