RISK OF DYING FROM CANCER BY SOCIO-DEMOGRAPHIC INDICATORS IN THE SLOVAK REPUBLIC

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SUMMARY

Aim: Cancer mortality distribution was investigated by detailed neoplasms groups, age, sex, marital status of deceased, and regions in the Slovak Republic, and examined how these determinants influence the odds of dying due to cancer.

Methods: A retrospective analysis of cancer mortality statistics registered in the Slovak Republic during the years 1996–2014. For this time period, data was available only on the underlying subgroups of cancer deaths, place of death, age, year, sex, and marital status. Binary logistic regression was applied for odds of dying calculation influenced by these socio-demographic factors.

Results: The most common are deaths from malignant neoplasms of digestive organs in males as well as females. The biggest difference among both genders is recognized in malignant neoplasms of lip, oral cavity and pharynx, where deaths among males are on average 7.9 times higher in comparison to females. As for place of death the Bratislava region reports the highest level of cancer mortality stated at 25.22% of all deaths, on the contrary the Banská Bystrica region reports only 21.40% of all deaths. Age has a negative influence on odds of dying due to neoplasms compared to all other causes of death by 1.7%. In all regions compared to the reference Bratislava region, the odds of dying from neoplasms are lower. Being female diminishes the odds of dying due to neoplasms by 25.7% compared to males. Yearly the relative ratio of dying from neoplasms increases with respect to all other causes of death. When single people are set as the reference category, the relation of the probability of death from cancer to the probability of death due to other causes of death is higher for married, divorced and widowed persons.

Conclusions: The results should be taken into account when comparing risk of dying due to cancer among people with the mentioned socio-demographic characteristics. Health policy makers should consider place of death and cancer types while planning hospital care units.

Key words: cancer mortality, odds of dying, socio-demographic factors, marital status

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INTRODUCTION

Oncology is a clinical branch of medicine concerned with the diagnosis and treatment of cancer. It focuses not only on the physical and mental functioning of humans, but also on social, family and environmental factors. The possibility of more effective treatment results from the understanding of the causes of cancer. Knowledge of the incidence of neoplasms in a certain geographic area, specific age group, or gender is a key issue, for example, in the case of adolescents when the occurrence of other cancer types compared with the elderly may occur (1).

In the Slovak Republic, two special medical centers are engaged in total diagnostics and treatment of patients suffering from cancer: The National Cancer Institute in Košice and St. Elizabeth Cancer Institute Hospital in Bratislava. Likewise, 73 regional hospitals operate oncology clinics for the treatment of neoplasms of adult patients. Comprehensive diagnostics and treatment of malignant neoplasms in children are engaged in the Clinic of Paediatric Haematology and Oncology in Bratislava, Department of Pediatric Oncology and Hematology in Children's Faculty Hospital of Košice, and Clinic of pediatric hematology and oncology in Banská Bystrica. Reporting cancer patients is established as obligatory and patients' long-term records are provided by National Cancer Registry of the Slovak Republic, which encourages a lifetime, long-term evidence of cancer patients from the Slovak Republic (2).

Incidence, Survival and Cancer Mortality

The consideration of incidence, survival and mortality rates together with monitoring geographical variation are important starting points for cancer epidemiology (3).

Data on cancer incidence in Slovakia are published annually by the National Cancer Registry of the Slovak Republic. The latest available data is from 2009 (4). The incidence rates in 2009 indicate increase of cancer cases for both sexes, but mainly among females. While in 2008 there were reported 30,144 new cancer cases (15,055 of males and 15,089 of females), in 2009 the total number of registered cases reached 31,466 new cancer cases (15,708 of males and 15,758 of females). This rapid increase and large occurrence in males is caused mainly by colorectal, lung and prostate cancers. In females, the dramatic increase of the overall number of cancer cases was primarily caused by breast cancer, non-melanoma skin cancer, female genital organs, colorectal and lung cancers (4). According to the GLOBOCAN project, in 2012 estimated cancer incidence for all ages and both sexes excluding non melanoma skin cancer is 24,045 of cancer cases in Slovakia (5).

Research Group EUROCARE 5 (6) processes data on a survival of target groups in European countries. These results confirmed that the long-term survival of young people aged 15–44 years on cancer diseases in Slovakia is lower than the European average, even as in the Czech Republic considering time period of diagnosis 2000–2007. The 5-year cumulative relative survival rate for all cancer types in Slovakia reached 69% compared to 76% in the Czech Republic, and an average of 76% in Europe. The biggest difference between the Slovak and Czech Republic was detected in cancer of the salivary glands (64% vs. 86%) and hypopharynx (14% vs. 34%).

Recent available data documents that cancers were responsible for the second largest proportion of non-communicable diseases mortality rate (21.7%) worldwide (7). Among men, the three most common sites of cancer mortality observed were lung (23.6%), liver (11.2%), and stomach (10.1%), comparing with breast (14.7%), lung (13.8%), and colorectum (9.0%) among women (3). In Slovakia, deaths for cancer represent the second leading cause of death after cardiovascular diseases. In 2014, total deaths from cancer accounted for 13.628 number of dead, what means 167 cases more than in 2013, and about 706 cases more than in 2012. In 2011, it was 13.030 cancer deaths (8). According to the OECD (9), the average crude mortality rate across OECD countries was 205 per 100,000 of persons, while Slovakia reported the third worst mortality rate 247 per 100,000 of inhabitants among OECD countries in 2013.

Determinants that influence dying from cancer were analyzed as low survival rates as well as increasing incidence and mortality rates of cancer point out the worsening health outcomes in Slovakia.

Cancer Mortality and Socio-demographic Factors

There is a strong relationship between socio-demographic groups of people and mortality by cause of death. Especially, cancer mortality is highly positive correlated with risk factors like tobacco use (10, 11), obesity (12), alcohol use (13). On the contrary, several studies have found evidence of a negative association between determinants such as education (14, 15) or occupation (16) and mortality, even between marital status and mortality. According to American mortality statistics, it is held that get married is regarded as an advantage of being healthier. Nevertheless, after adjustment for age, the mortality rate for the married is lower and life expectancy is higher than for unmarried (17). Limited studies have been conducted on the effect of marital status on mortality, and even lesser on cancer mortality. However, Rogers et al. (18) found that married individuals living together and with their children have the lower risk of dying than their unmarried counterparts. Surprisingly, in the Czech Republic, divorce considered as a psychological factor was significant factor in explaining cancer mortality, when for every 1% increase in the level of divorce, mortality is expected to increase by 0.27% (19). In a recent study about cancer mortality in Swedish persons with diabetes mellitus type 2, marital status was not associated with overall cancer mortality, however, married men reported a 33% lower risk of prostate cancer mortality compared to single men (20).

High cancer mortality differences may exist between the regions of one country considering stratification by sex and age structure at least. In addition, some types of cancer, for example lung neoplasms can serve as a proxy for smoking habits related deaths in the region. In Germany, regional mortality among men was predominantly explained by lung cancer (21). On the other hand, in Poland mortality due to malignant neoplasms was not caused by regional differences (22).

The aim of this study is to conduct analysis of cancer deaths distribution in the regions of Slovak Republic and examine all available socio-demographic factors in the long term that can influence the odds of dying, or not dying due to cancer.

MATERIALS AND METHODS

Death records in Slovakia during 1996–2014 are examined to investigate socio-demographic differentials in cancer mortality. Data on sex, age, place of death, cause of death and marital status are available from 1996 to 2014. Others socio-demographic data like education or occupation are available only from 2011, so they are excluded from analysis. The study of the population covers all deceased of the Slovak Republic from 1996 to 2014.

Based on The Nomenclature of Territorial Units for Statistics (NUTS III) classification, Slovakia is divided into the 8 regions with the mean number of inhabitants considering time period from 1996 to 2014: Bratislava region (613,236), Trnava region (553,993), Trenčín region (601,946), Banská Bystrica region (658,923), Košice region (773,880), Nitra region (706,308), Prešov region (797,245), Žilina region (692,602).

Binary logistic regression which is a special case of the generalized linear model, meaning analogous to linear regression, was used. Binary logistic regression overcomes many of the restrictive assumptions of linear regressions. While using binary logistic regression, dependent variable does not need to be normally distributed. Further, this method does not require a linear relationship between the dependent variable and regressor, residuals need to be independent but not necessarily normally distributed. The only assumption to be satisfied is an assumption of non-multicollinearity of explanatory variables which is fulfilled in this case.

In binary logistic regression, the dependent variable is binary, thus it has a dichotomous nature. Binary logistic regression measures the odds of occurrence of studied phenomenon with probability π, against non-occurrence of given phenomenon with probability $1-\pi$. The part of these two values represents the ratio of the chances that explained variable reaches one out of mentioned category (occurrence vs. non-occurrence). The

odds of occurrence of the phenomenon is given as following: $\pi/1-\pi$. Then, the probability is expressed as $\pi = odds/1+odds$. As mentioned above, logistic regression is based on the general linear model, in which the asymmetry of values is removed by transformation of the model by natural logarithm. Logit is then defined as $\ln(odds) = ln\,(\pi/1-\pi)$ with the domain $(-\infty; \infty)$. Logit model is than can be expressed in its basic form as: $\ln(\pi/1-\pi) = \beta_0+\beta_1X_1+\beta_2X_2+\ldots+\beta_nX_n$, where $\beta_0, \beta_1 \ldots, \beta_n$ are the parameters of the model and π is the conditional mean value of the response variable (23). Logistic regression estimates the probability that the phenomenon occurs. We assume that the phenomenon occurs when the probability is higher than the chosen threshold, which is usually set to 0.5. (24).

In the analysis, the dependent variable is death diagnosis and the explanatory variables are age, region, sex and marital status. Dependent variable takes the value 0, when one died for other cause than neoplasm and value 1 in cases, when one died because of neoplasm. Independent, explanatory variables are four and are coded as follows. Age is a scalar variable which reaches values from 0 to 108, thus youngest dead man had 0 years and the oldest one had 108. Year is continuous variable and express the year of death. The region is nominal variable reaching 8 levels: Bratislava region, Trnava region, Trenčín region, Nitra region, Žilina region, Banská Bystrica region, Prešov region and Košice region. The variable region represents the place where one died. It does not represent the place of birth, or place of living, but place of death. Place of death is supposed to be a socio-demographic characteristic, because we assume, that individual dies in their region of living. Here we keep in mind ones´ home, or district hospital. Gender is a binary categorical variable which is coded 0 for males and 1 for females. Marital status is a categorical variable which achieves four levels: single, married, divorced and widowed.

RESULTS

Incidence and Cancer Types Mortality

In the Slovak Republic, 997.165 persons died within the period of 1996–2014. Every fifth person died because of neoplasms. More precisely, 228,025 deaths are caused by neoplasms, what equals to 22.9% of all deaths. Table 1 depicts exact counts of deaths caused by a particular type of cancer and its percentage representation within time period of 1996–2014. Neoplasms are categorized according to the International Statistical Classification of Diseases (C00-D48) designed by the World Health Organization, including non-melanoma cancer.

Eyeballing Table 1 provides the most serious malignant neoplasms of digestive organs (C15-C26) accounting for 35.3%, malignant neoplasms of respiratory and intrathoracic organs (C30-C39) presenting 19.8%, malignant neoplasm of breast (C50), malignant neoplasms of female genital organs (C51-C58), malignant neoplasms, stated or presumed to be primary, of lymphoid, haematopoietic and related tissue (C81-C96), malignant neoplasms of urinary tract (C64-C68) and malignant neoplasms of lip, oral cavity and pharynx (C00-C14) demonstrating 6% in average. Others diagnoses stay at the value below 5%.

Regional Mortality Distribution by Sex and Cancer Types

Table 2 contains distribution of deaths caused by neoplasms among regions and gender. Table 2 shows 58.3% of deaths caused by neoplasms in men.

Totally, the biggest differences among genders, where males clearly dominate, are in subgroups of malignant neoplasms of lip,

Table 1. *Cancer type distribution from 1996 to 2014*

Type of neoplasm	Frequency	Percent
Malignant neoplasms of lip, oral cavity and pharynx (C00-C14)	11,636	5.1
Malignant neoplasms of digestive organs (C15-C26)	80,584	35.3
Malignant neoplasms of respiratory and intrathoracic organs (C30-C39)	45,137	19.8
Malignant neoplasms of bone and articular cartilage (C40-C41)	970	0.4
Melanoma and other malignant neoplasms of skin (C43-C44)	3,962	1.7
Malignant neoplasms of mesothelial and soft tissue (C45-C49)	1,901	0.8
Malignant neoplasm of breast (C50)	15,027	6.6
Malignant neoplasms of female genital organs (C51-C58)	14,784	6.5
Malignant neoplasms of male genital organs (C60-C63)	10,680	4.7
Malignant neoplasms of urinary tract (C64-C68)	12,356	5.4
Malignant neoplasms of eye, brain and other parts of central nervous system (C69-C72)	6,707	2.9
Malignant neoplasms of thyroid and other endocrine glands (C73-C75)	1,041	0.5
Malignant neoplasms of ill-defined, secondary and unspecified sites (C76-C80)	5,441	2.4
Malignant neoplasms, stated or presumed to be primary, of lymphoid, haematopoietic and related tissue (C81-C96)	14,236	6.2
Malignant neoplasms of independent (primary) multiple sites (C97)	1,672	0.7
Benign neoplasms (D10-D36)	438	0.2
Neoplasms of uncertain or unknown behaviour (D37-D48)	1,453	0.6
Total	228,025	100.0

Table 2. *Cross tabulation frequency – cancer type, region, sex*

Type of neoplasm		Region								
		Bratislava	Trnava	**Trenčín**	Nitra	**Žilina**	Banská Bystrica	Prešov	Košice	Total
C00-C14	Male	866	1,147	970	1,782	1,310	1,390	1,395	1,474	10,334
	Female	147	141	137	239	145	182	143	167	1,301
	Total	1,013	1,288	1,107	2,021	1,455	1,572	1,538	1,641	11,635
C15-C26	Male	5,298	5,286	5,385	7,271	5,549	5,892	5,917	6,185	46,783
	Female	4,382	3,759	3,668	5,479	3,946	4,054	3,945	4,563	33,796
	Total	9,680	9,045	9,053	12,750	9,495	9,946	9,862	10,748	80,579
C30-C39	Male	3,683	4,336	3,908	5,616	4,575	4,925	4,549	5,097	36,689
	Female	1,273	871	841	1,250	850	1,185	784	1,391	8,445
	Total	4,956	5,207	4,749	6,866	5,425	6,110	5,333	6,488	45,134
C40-C41	Male	36	57	66	89	81	85	75	68	557
	Female	42	42	34	59	54	59	69	54	413
	Total	78	99	100	148	135	144	144	122	970
C43-C44	Male	287	223	260	294	248	271	244	249	2,076
	Female	246	184	186	285	232	295	219	239	1,886
	Total	533	407	446	579	480	566	463	488	3,962
C45-C49	Male	147	103	122	129	100	103	135	137	976
	Female	129	85	107	113	103	114	134	140	925
	Total	276	188	229	242	203	217	269	277	1,901
C50	Male	36	24	19	30	26	27	15	20	197
	Female	2,224	1,725	1,640	2,357	1,675	1,842	1,482	1,885	14,830
	Total	2,260	1,749	1,659	2,387	1,701	1,869	1,497	1,905	15,027
C51-C58	Female	1,942	1,626	1,631	2,329	1,702	1,879	1,683	1,989	14,781
	Total	1,942	1,626	1,631	2,329	1,702	1,879	1,683	1,989	14,781
C60-C63	Male	1,374	1,146	1,219	1,454	1,302	1,390	1,385	1,408	10,678
	Total	1,374	1,146	1,219	1,454	1,302	1,390	1,385	1,408	10,678
C64-C68	Male	997	905	953	1,197	1,023	1,157	1,044	1,038	8,314
	Female	584	490	456	529	483	508	491	501	4,042
	Total	1,581	1,395	1,409	1,726	1,506	1,665	1,535	1,539	12,356
C69-C72	Male	392	391	384	522	420	383	496	554	3,542
	Female	391	345	342	479	395	391	397	425	3,165
	Total	783	736	726	1,001	815	774	893	979	6,707
C73-C75	Male	56	48	47	60	57	52	52	52	424
	Female	78	59	67	90	86	84	79	74	617
	Total	134	107	114	150	143	136	131	126	1,041
C76-C80	Male	367	319	312	591	374	346	380	307	2,996
	Female	368	268	236	470	329	256	271	247	2,445
	Total	735	587	548	1,061	703	602	651	554	5,441
C81-C96	Male	872	754	818	1,039	1,050	960	989	1,023	7,505
	Female	894	726	718	949	862	860	856	864	6,729
	Total	1,766	1,480	1,536	1,988	1,912	1,820	1,845	1,887	14,234
C97	Male	89	115	193	139	151	63	50	147	947
	Female	67	85	140	107	127	62	44	93	725
	Total	156	200	333	246	278	125	94	240	1,672

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Type of neoplasm		Region								
		Bratislava	Trnava	**Trenčín**	Nitra	**Žilina**	Banská Bystrica	Prešov	Košice	Total
D10-D36	Male	20	18	17	26	22	23	43	19	188
	Female	36	32	22	35	28	23	46	28	250
	Total	56	50	39	61	50	46	89	47	438
D37-D48	Male	104	76	87	107	156	58	96	73	757
	Female	110	65	77	93	119	54	98	80	696
	Total	214	141	164	200	275	112	194	153	1,453
Total	Male	14,624	14,948	14,760	20,346	16,444	17,125	16,865	17,851	132,963
	Female	12,913	10,503	10,302	14,863	11,136	11,848	10,741	12,740	95,046
	Total	27,537	25,451	25,062	35,209	27,580	28,973	27,606	30,591	228,009
% of deaths caused by Neoplasms on total number of deaths in region		25.22%	24.37%	22.71%	23.53%	22.60%	21.40%	21.78%	21.95%	22.87%

oral cavity and pharynx (C00-C14) where deaths for males are an average of 7.9 times higher compared with females; malignant neoplasms of respiratory and intrathoracic organs (C30-C39) presents 4.3 times higher values for men; malignant neoplasms of urinary tract (C64-C68) and malignant neoplasms of digestive organs (C15-C26) accounts for 2.1 and 1.4 times upper number of males deaths respectively. As for regions, percentage of deaths caused by Neoplasms on total number of deaths in region is highest in Bratislava region and Trnava region; and lowest in Banská Bystrica region and Prešov region.

Logistic Regression

Results of binary logistic regression are shown in Table 3. Here the benign neoplasms do not enter our analysis, as those are not supposed to be a cancer. All obtained regression coefficients are statistically significant and also model as a whole is statistically significant.

Table 3 reveals some startling findings. Age has a negative influence on odds of dying because of neoplasms to the probability of death because of other causes of death. It means, that a one-unit increase in age reduces the chance of dying because of

Table 3. *Odds of dying from neoplasms by age, year, region, gender, and marital status*

	B coefficient	Standard error	Wald	Degrees of freedom	p-value	Odds ratio
Age	−0.017	0.000	8,888.693	1	< 0.001	0.983
Year	0.013	0.000	858.173	1	< 0.001	1.013
Region			1,332.240	7	< 0.001	
Trnava	−0.094	0.010	84.146	1	< 0.001	0.910
Trenčín	−0.180	0.010	310.184	1	< 0.001	0.835
Nitra	−0.129	0.009	186.532	1	< 0.001	0.879
Žilina	−0.203	0.010	413.683	1	< 0.001	0.816
Banská Bystrica	−0.267	0.010	739.163	1	< 0.001	0.766
Prešov	−0.264	0.010	703.745	1	< 0.001	0.768
Košice	−0.266	0.010	752.414	1	< 0.001	0.766
Gender – females	−0.297	0.005	3,801.019	1	< 0.001	0.743
Marital status			22,154.061	3	< 0.001	
Married	1.108	0.010	12,852.983	1	< 0.001	3.028
Divorced	0.615	0.012	2,522.592	1	< 0.001	1.851
Widowed	0.456	0.011	1,684.377	1	< 0.001	1.577
Constant	−0.585	0.013	1,936.023	1	< 0.001	0.557

Bratislava region is the reference category for region.
Single people are the reference category for marital status.

neoplasm, controlling for other explanatory variables. This chance is reduced by each additional year of living by 1.7%. This chance is yearly reduced only with respect to other causes of deaths. This conclusion means, that the older one gets the odds of dying because of neoplasm decrease, but it does not mean, that this chance decreases for another diagnosis. On the contrary, chance of dying for other reasons than neoplasm increases with getting older. Time coefficient is positive, what signifies that from year to year, the relative risk of dying because of cancer is bigger as compared to other causes of death. This chance is bigger by 1.3%.

Concerning variable region of dying, reference category was set Bratislava region. In conclusion, in every region comparing to reference Bratislava region, the odds of dying because of neoplasms are lower, in context of the fact. The odds of dying due to neoplasms are by 9% lower in Trnava region, 16.5% lower in Trenčín region, 12.1% lower in Nitra region, 18.4% lower in Žilina region, 23.4% lower in Banská Bystrica region, 23.2% lower in Prešov region and 23.4% lower in Košice region.

In case of women, the odds of dying decrease due to neoplasms by 25.7% in comparison to men, with respect to other causes of death and while controlling for other variables in the regression.

Concerning marital status, where single people were set as the reference category, the findings are following: the relation of the probability of death because of cancer to the probability of death because of other causes of death is 3 times bigger for married individuals, by 85% higher for divorced people and by 58% higher for widowed people as compared to single people and controlling for all explanatory variables.

DISCUSSION

It was found out that the most frequent are deaths from malignant neoplasms of digestive organs accounting for 35.3% of all cancer deaths. Proportion of males among all the deceased from Neoplasms is 58.3%. Region with lowest percentage of deaths caused by Neoplasms on total number of deaths is Banska Bystrica region with 21.40%. Contrary, region with highest percentage of deaths caused by Neoplasms on total number of deaths is Bratislava region, with 25.22%.

Based on logistic regression, negative effects of age on odds of dying were observed what might be also encouraged by the fact that an average age of dying due to neoplasms is 67 years, while average age of dying because of other causes of death is 72 years. The Slovak female population exhibits a relatively lower risk group with relation to cancer mortality. High gap between sexes is especially noticeable in mortality from lip, oral cavity, pharynx, larynx and respiratory organs (Table 2), what likely results from lesser female proportion on tobacco use. Similarly, low alcohol consumption in women is reflected in their lower mortality from digestive organs, mainly neoplasms of liver or colorectal cancer (Table 2) (27). The findings of gender gap are consistent with the studies in Germany (21).

The analysis shows that odds of dying due to cancer are lower in every region in comparison to Bratislava region. For these explanations, detailed analyses of causes of cancer deaths should have to be conducted in the future. However, the National Cancer Institute is situated in Bratislava, thus people from all around the Slovakia die there and it can distort data.

The opposite relationship for married people and cancer mortality compared to the international studies mentioned in the Introduction section was observed. One of the explanations can relate to smaller sample of married or divorced people in Slovakia compared to the sample in the United States, what can bias the results and lead to the contradictory conclusions. In addition, from 2000 to 2014, the crude divorce rates in the United States decreased by 20‰ (26), while in Slovakia an increase by 12.8‰ is evident (27). The findings regarding marital status are a little bit fetched, as according to the Statistical Office of the Slovak Republic the average age of marriage in Slovakia is 31.1 years. At this age, only a few people die for the reason of neoplasms. On the other hand, cancer starts to be a serious problem in mid thirties and late thirties of a person, when majority of population is already married. Cancer is not a serious population problem in age under thirties, so this fact does not affect marital status. The findings are most likely influenced by suppression effect which usually occurs in the binary logistic regression. Suppression effect is inducted by a suppressor variable which increases the predictive validity of another variable (or set of variables) by its inclusion in a regression, whilst suppressor variable has a zero correlation with the dependent variable. Furthermore, it has to be taken into account that variable of marital status for the discussion is hard to interpret since the term “single” is unclear in research terminology. Many couples live together in cohabitation, but they are not officially married. In spite of this fact, they have the same life habits and behaviour as married ones. On the other hand, some married people live separately, but they are listed as married. It is proved that married persons report a higher level of physical and psychological well-being than their unmarried counterparts (28). However, an implication of marital status on mortality patterns is not direct since this relationship has a very strong psychological effect.

CONCLUSIONS

This paper focused primarily on the burden of cancer types and in spite of some limitations serves for implementing cancer control to region specific priorities, for example medical equipment, bed capacity or personnel requirements. Risk of dying from cancer should be controlled in the patients considering their socio-demographic characteristics, with the aim to predict future health care costs. Mortality rate indicators reflect the effectiveness of cancer prevention, diagnosis, treatment and rehabilitation, so they should be monitored and updated in one health care system of each country.

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Conflict of Interests

None declared

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