RESEARCH ARTICLE

Calculation of Life-Time Death Probability due Malignant Tumors Based on a Sampling Survey Area in China

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Abstract

Purpose: To calculate the probability of one person's life-time death caused by a malignant tumor and provide theoretical basis for cancer prevention. Materials and Methods: The probability of one person's death caused by a tumor was calculated by a probability additive formula and based on an abridged life table. All data for age-specific mortality were from the third retrospective investigation of death cause in China. Results: The probability of one person's death caused by malignant tumor was 18.7% calculated by the probability additive formula. On the same way, the life-time death probability caused by lung cancer, gastric cancer, liver cancer, esophageal cancer, colorectal and anal cancer were 4.47%, 3.62%, 3.25%, 2.25%, 1.11%, respectively. Conclusions: Malignant tumor is still the main cause of death in one's life time and the most common causes of cancer death were lung, gastric, liver, esophageal, colorectal and anal cancers. Targeted forms of cancer prevention and treatment strategies should be worked out to improve people's health and prolong life in China. The probability additive formula is a more scientific and objective method to calculate the probability of one person's life-time death than cumulative death probability .

Keywords: Malignant tumor - probability additive formula - death probability

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Introduction

There are at least two methods used to find the probability of death by cancer: the one is cumulative death probability (Sun, 2008), the other one is probability additive formula (Zhang, 2010). The former should be applied in medical and non-medical fields, but affected by the cut-off time. Therefore we recommend the latter method to calculate life-time death probability.

Cancer incidence and mortality have increased sharply in China in recent years. The 2012 Chinese Cancer Registry Annual Report, published by the National Cancer Registry, pointed out that the probability of one person's life-time death caused by malignant tumor was 13% in China (Inoue et al., 2000; Hao et al., 2012), which was calculated based on a cumulative death probability from 0-74-year-old residents. It does not including a person's whole life time, as someone maybe lived more than 74 year old and it does not consider the risk of death competition. In this article, we recommend different method to calculate the probability of one person's life-time death caused by a malignant tumor: probability additive formula. This method considers the risk of death competition, and a variety of death causes. The aim of this study is to calculate the probability of life time death caused by a malignant tumor by probability additive formula.

Materials and Methods

Data

All data (age-specific mortality) was from the third retrospective investigation of death cause in the sample area in China (attached list 1, P52-53), (Chen, 2008). This survey was covering 213 counties throughout the country, conducted by health ministry of the people's republic of China.

Statistical analysis

Based on an abridge life table (Sun et al., 2006), the probability additive formula was taken to calculate the probability of one person's life-time death caused by a malignant tumor. The series of formulas is as follows:

$$q_{\chi}=\sum_{i} q_x^i \quad (1)$$

$$D_{\chi}=\sum_{i} \mathbf{D}_{\mathbf{x}}^{\mathbf{i}} \quad (2)$$

$$r_x^i=D_x^i \div D_x=m_x^i \div m_x \quad (3)$$

$$q_x^i=r_x^i q_{\chi} \quad (4)$$

$$d_x^i=r_x^i d_{\chi} \quad (5)$$

$$P_x^i=\sum_{x}^{w} d_x^i \div l_x \quad (6)$$

$$P_0^i=\sum_{x=0}^{w} d_x^i \div l_0 \quad (7)$$

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Table 1. Calculation on One Person's Life-Time Death Probability of Malignant tumor on Sampling Survey Area in China

χ	$m\chi$	m^i_χ	q_χ	$l\chi$	$d\chi$	r^i_χ	d^i_χ	Σd^i_χ	P^i_χ
0~	0.0113	0.0001	0.0113	100000	1133	0.0073	8	18735	0.1873
1~	0.0008	0.0001	0.0033	98867	329	0.0603	20	18727	0.1894
5~	0.0003	0.0000	0.0017	98538	167	0.1067	18	18707	0.1898
10~	0.0003	0.0000	0.0014	98371	136	0.1376	19	18689	0.1900
15~	0.0005	0.0001	0.0026	98235	260	0.1354	35	18670	0.1901
20~	0.0007	0.0001	0.0034	97975	330	0.1076	36	18635	0.1902
25~	0.0007	0.0001	0.0036	97645	347	0.1350	47	18599	0.1905
30~	0.0010	0.0002	0.0052	97298	502	0.1847	93	18553	0.1907
35~	0.0016	0.0004	0.0081	96796	781	0.2454	192	18460	0.1907
40~	0.0024	0.0007	0.0117	96016	1126	0.2977	335	18268	0.1903
45~	0.0032	0.0012	0.0161	94890	1529	0.3552	543	17933	0.1890
50~	0.0056	0.0021	0.0278	93361	2598	0.3700	961	17390	0.1863
55~	0.0088	0.0032	0.043	90763	3905	0.3619	1413	16429	0.1810
60~	0.0129	0.0044	0.0627	86858	5445	0.3361	1830	15016	0.1729
65~	0.0218	0.0064	0.1035	81413	8427	0.2925	2465	13185	0.1620
70~	0.0387	0.0094	0.1766	72985	12887	0.2434	3137	10720	0.1469
75~	0.0623	0.0118	0.2697	60098	16206	0.1890	3064	7584	0.1262
80~	0.1050	0.0139	0.4157	43892	18247	0.1322	2412	4520	0.1030
85+	0.1623	0.0133	1.0000	25646	25646	0.0822	2108	2108	0.0822

*the age-specific mortality is cited by reference(Sun, 2008), attached list 1, P52-53

(1) q means the death probability, horn x means age group, horn i means the cause of death; (2) D means the actual death; (3) m means mortality, r means proportional mortality; (5) d means death toll on the life table. (6) l means survival number from the life table; (7) w means the oldest age group.

In the end, P^i_0 of age group 0 is representative of one person's life-time death probability (Zhou et al., 1991).

Results

The death probability (P^i_0) during a life time is actually a composition index with the summation of each probability of death equal to 1. It is not affected by population composition since it is based on the life table (Sun et al., 2006), which is not influenced by the population composition. However, the ordinary proportional mortality (22.32%, is the number of deaths due to malignant tumor divided by the total number of deaths) tends to be affected by population composition (Chen, 2008). It should be noted that the proportional mortality is consistent with (P^i_0) when the population composition equals the survival number l_χ on the life table.

By using probability additive formula and based on abridge life table (Sun et al., 2006) we found one person's life-time death probability caused by malignant tumor in China is 18.73% (shown in Table 1), which was different from 13% calculated by cumulative death probability, published by 2012 Chinese Cancer Registry Annual Report. On the abridge life table, χ is age group, m_χ is age-specific mortality, m^i_χ is age-specific mortality caused by tumor, q_χ is age-specific death probability, l_χ is age-specific survival number, d_χ is age-specific death toll, r^i_χ is age-specific proportional mortality caused by tumor, d^i_χ is age-specific death toll caused by tumor, $\sum_x^w d^i_x$ is all-age death toll caused by tumor, P^i_χ is age-specific life-time death probability caused by tumor, P^i_0 is one person's life-time death probability caused by tumor.

Table 2. Main Death Caused by Different Malignant tumors on Sampling Areas in China

Name of tumor	Mortality (1/10 million)	Accounts for the cause of death(%)	Cumulative rate (0-74age) (100%)	Death probability ofone life (%)
All malignant tumor	135.88	22.32	14.13	18.73
Lung cancer	30.84	5.07	3.33	4.47
Stomach Cancer	24.71	4.06	2.63	3.62
Liver Cancer	26.26	4.31	2.72	3.25
Esophageal cancer	15.21	2.5	1.66	2.25
Colorectal and anal cancer	7.42	1.22	0.73	1.11

Using the same method, only replacement age-specific death toll caused by tumor for age-specific death toll caused by lung cancer, gastric cancer, liver cancer, esophageal cancer, colorectal and anal cancer, respectively, one person's life-time death probability caused by different malignant tumor was carried out. The result of one person's life-time death probability caused by lung cancer, gastric cancer, liver cancer, esophageal cancer, colorectal and anal cancer was 4.47%, 3.62%, 3.25%, 2.25%, 3.25%, respectively (Table 2).

Discussion

Cumulative mortality widely used by lots of references (Inoue et al., 2003; Kim, 2007; Andersen et al., 2012; Latouche et al., 2013), can indicate the dangerous degree of death cause and be uninfluenced by population composition. Cumulative risk belongs to a probability index, that is, it assumes no other causes of death. The calculative formula of the death probability of certain person during special age group (commonly 0~74 years) is $Q^i_\chi = 1-\prod_{i=0}^{x}(1-q^i_i)$. It can be regarded as a strength index without the characteristics of an indicator of composition. The drawback of cumulative risk is that it cannot calculate the probability of death by during a person's life time due to complications with statistical theory. In this case, although there is only one cause of death, the death probability of everyone is 100% in the end; the only

difference is the length of life time.

The 2012 China Cancer Registration Report concluded that the cumulative death probability of Chinese residents between the ages 0 to 74 is 13%. The third death retrospective investigation also reported (Chen, 2008) that the cumulative death probability of Chinese residents between the age of 0 to 74 due to malignant tumors is 14.13%. Taking into account the existence of multiple causes of death, in the context of competing risks, the death probability of one person during life time was 18.73%, which was calculated by the probability additive formula. Therefore, death probability 18.73% is more objective than 13% (Hao et al., 2012) or 14% (Chen, 2008) to reflect the cancer hazard level.

It can be seen from Table 2 that the mortality (26.26/10 million) and cumulative rate of liver cancer (2.72%), was higher than the mortality (24.71/10 million) and cumulative rate (2.63%) of stomach cancer, respectively, but the death probability of liver cancer (3.25%) is lower than that of gastric cancer (3.62%). The main reason is that the mortality is affected by age composition and not considering competing risks. Secondly, the liver cancer mortality of age 40 to 45 (per 21.45/10 million) was more than twice the mortality caused by stomach cancer (8.21/10 million); while at higher age groups (80 to 84 year old), the mortality of stomach cancer (per 296.76/10 million)was higher than that of the liver cancer (per 187.55/10 million).

The people dying from liver cancer tend to be younger, while most people who die from gastric cancer tend to be older. Therefore, one person's life-time death probability of liver cancer was lower than that of gastric cancer, considering the competitive death risks.

Malignant tumor is still the main cause of death in one's life time and the most common causes of cancer death were lung cancer, gastric cancer, liver cancer, esophageal cancer, colorectal and anal cancer, which was different from the result of the common causes of cancer death were lung cancer, liver cancer and colorectal cancer in Association of Southeast Asian Nations (Kimman et al, 2012). Therefore, targeted forms of cancer prevention and treatment strategies should be work out to improve people's health and prolong life in China.

By the way, the additive formula of probability would be also used to calculate the life-time incidence probability. The formula of life-time incidence probability of malignant tumors is $P_0^i=(\sum_{x=0}^{w} I_x^i)\div l_0$, $I_x=f_x^i l_x$ is for survival number on life table.

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