

RESEARCH ARTICLE

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Comparison of Life-Time Death Probability due to Malignant Tumors in Different Regions of China Based on Chinese Surveillance Sites

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Abstract

Objective: To estimate and comparably analyze the life-time death probability (LDP) caused by malignant tumors in different regions in 2004 and 2014. **Methods:** LDP was calculated by a probability additive formula and based on an abridged life table. Data on age-specific mortality was obtained from the National Cause-of- Death Surveillance Dataset in 2014 using surveillance sites in China and data on age-specific mortality was collected from the third retrospective investigation of death cause in China in 2004. **Results:** LDP caused by malignant tumors, lung cancer, gastric cancer, liver cancer, esophageal cancer, colorectal, and anal cancer were 19.2%, 5.6%, 2.8%, 2.8%, 1.7%, 1.3%, respectively. In addition, we calculated LDP caused by malignant tumors in three different regions of China. LDP caused by malignant tumors were 21.2%, 6.1%, 3.1%, 2.8%, 2.0%, and 1.5% in the eastern region, were 18.3%, 5.5%, 2.7%, 3.0%, 1.5%, and 1.1% in the central region, and were 16.7%, 4.6%, 2.3%, 2.8%, 1.6%, and 1.2% in the western region, respectively. Additionally, LDP caused by malignant tumors in 2004 and 2015 were compared. We found that LDPs caused by malignant tumors, lung cancer, and colorectal cancer have increased in the past decade, while LDPs caused by gastric cancer, liver cancer, and esophageal cancer have experienced a decreasing trend. **Conclusions:** Malignant tumors were still the main cause of death in one's life time, giving rise to LDP. LDP caused by malignant tumours has two divisions. First, traditional upper digestive system cancers related to long-term chronic infection, such as esophageal cancer, gastric cancer, and liver cancer, which has shown a significant downward trend. Second, lung and colorectal cancers related to the environmental factors and lifestyle, which are on the rise.

Keywords: Malignant tumor- probability additive formula- life-time death probability- mortality

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Introduction

Cancer incidence and mortality rate have increased sharply in China in recent years. In 2014, 3.804 million new cases with malignant tumors were diagnosed and 2.296 million cancer deaths were reported in China. The cancer incidence rate was 278.07 per 100,000 people. The its mortality rate was 167.9 per 100,000 people (Chen et al., 2018). The incidence and mortality of diseases are of public health and epidemiological significance for each country. But for individuals, if the cancer is unfortunately diagnosed, it will instantly become an absolute misfortune in personal life. A life-time death probability (LDP) is based on the principle of probability addition. The death probability (P^i) 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. LDP is quite different from the proportional mortality affected by population composition. Our previous study reported that LDP caused

by a malignant tumor was 18.7% in 2004 (Yuan et al., 2014). However, as a country with a huge land area and a wide range of people's living habits in different regions, the overall data obviously cannot reflect the differences among regions. Therefore, this study was attempted to compare LDP caused by malignant tumors in different areas of China.

Materials and Methods

Data Collection

Data on age-specific mortality was obtained from the National Cause-of- Death Surveillance Dataset in 2014 using surveillance sites in China (China CDC and National HFPC, 2015). This dataset was collected through national disease surveillance system (605 monitoring stations) by the National Health and Family Planning Commission of the People's Republic of China.

Data on age-specific mortality was collected from the third retrospective investigation of death cause in the

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sample area in China in 2004 (Chen, 2008) . This survey covered 213 counties throughout the country, and it was conducted by the National Health Ministry of the People’s Republic of China.

Division of East, Central, and West Regions

According to the standards provide by the National Bureau of Statistics, China is divided into three regions, namely eastern, central, and western with respect to natural geography (Chen, 2008) .

The eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan.

The central region involves Heilongjiang, Jilin, Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan.

The western region comprised of Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

Statistical analysis

Based on an abridge life table (Sun and Xu, 2006), the probability additive formula was taken to calculate the LDP caused by malignant tumors. The series of formulas were as follows:

$$q_x = \sum_i q_x^i \tag{1}$$

$$D_x = \sum_i D_x^i \tag{2}$$

$$r_x^i = \frac{D_x^i}{D_x} = \frac{m_x^i}{m_x} \tag{3}$$

$$q_x^i = r_x^i q_x \tag{4}$$

$$d_x^i = r_x^i d_x \tag{5}$$

$$P_x^i = \frac{\sum_x d_x^i}{l_x} \tag{6}$$

$$P_0^i = \frac{\sum_{x=0}^w d_x^i}{l_0} \tag{7}$$

(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; and (7) w means the oldest age group.

In P_0^i of age group, 0 is representative of one person’s LDF (Zhou TS, Chen CG ,1991).

Results

By using probability additive formula and based on abridge life table, we found that LDP caused by malignant tumors was 19.21% in China in 2014 (Table 1). On the abridge life table, x means age group, m_x refers to age-specific mortality, m_x^i indicates age-specific mortality caused by tumors, q_x shows age-specific death probability, l_x means age-specific survival number, d_x is representative of age-specific death toll, r_x^i represents age-specific proportional mortality caused by tumors, d_x^i means age-specific death toll caused by tumors, \sum_x^i refers to all-age death toll caused by tumors, P_x^i addresses age-specific LDF caused by tumors, and P_0^i is one person’s LDF caused by tumors.

In addition, we discovered that LDP caused by lung cancer, gastric cancer, liver cancer, esophageal cancer, colorectal and anal cancer was 5.6%, 2.8%, 2.8%, 1.7%,

Table 1. One Person’s LDP Caused by Malignant Tumor Using Surveillance Sites in China

x (1)	m_x (2)	m_x^i (3)	q_x (4)	l_x (5)	d_x (6)	r_x^i (7)=(3)/(2)	d_x^i (8)=(6)*(7)	\sum_x^i (9)	P_x^i (10)=(9)/(5)
0~	0.0046	0	0.0046	100,000	461	0.0093	4	19,210	0.1921
1~	0.0005	0	0.002	99,539	199	0.0805	16	19,205	0.1929
5~	0.0002	0	0.0011	99,341	107	0.1394	15	19,189	0.1932
10~	0.0003	0	0.0013	99,233	130	0.15	19	19,174	0.1932
15~	0.0004	0	0.0018	99,104	178	0.1364	24	19,155	0.1933
20~	0.0004	0.0001	0.0019	98,926	186	0.1337	25	19,131	0.1934
25~	0.0006	0.0001	0.0031	98,740	309	0.1518	47	19,106	0.1935
30~	0.0009	0.0002	0.0043	98,430	419	0.2056	86	19,059	0.1936
35~	0.001	0.0003	0.0052	98,012	509	0.2592	132	18,973	0.1936
40~	0.0017	0.0005	0.0087	97,503	847	0.3078	261	18,841	0.1932
45~	0.0023	0.0008	0.0114	96,656	1105	0.3487	385	18,580	0.1922
50~	0.0044	0.0017	0.0216	95,551	2,066	0.3813	788	18,195	0.1904
55~	0.0056	0.0023	0.0275	93,485	2,570	0.4053	1042	17,407	0.1862
60~	0.0101	0.0039	0.0495	90,915	4,498	0.3854	1734	16,366	0.18
65~	0.0176	0.006	0.0841	86,417	7,265	0.3406	2474	14,632	0.1693
70~	0.0282	0.0079	0.1317	79,152	10,425	0.2809	2928	12,157	0.1536
75~	0.0437	0.0102	0.1969	68,727	13,530	0.2333	3156	9,229	0.1343
80~	0.0805	0.0127	0.3351	55,197	18,498	0.1572	2908	6,073	0.11
85+	0.1664	0.0144	1	36,699	36,699	0.0863	3165	3,165	0.0863

Note: the age-specific mortality is cited by reference [3], 2015, Chapter VII,244-248.

Table 2. Main Death Caused by Different Malignant Tumors According to Surveillance Sites in China between 2014 and 2004

Name of tumor	Whole area		Eastern area		Middle area		Western area	
	Mortality (1/million)	death probability(%)	Mortality (1/million)	death probability(%)	Mortality (1/million)	death probability(%)	Mortality (1/million)	death probability(%)
All malignant tumor	155.36	19.21	175.41	21.18	144.66	18.29	139.19	16.74
Lung cancer	43.03	5.56	49.23	6.13	41.20	5.47	35.98	4.62
Stomach Cancer	21.10	2.77	24.14	3.06	19.91	2.69	18.05	2.31
Liver Cancer	26.22	2.83	26.40	2.75	26.23	2.96	25.93	2.75
Esophageal cancer	12.84	1.71	15.22	1.96	10.53	1.47	11.37	1.60
Colorectal and anal cancer	9.65	1.30	11.42	1.53	8.27	1.10	8.83	1.16

Note: the age-specific mortality is cited by reference [3], 2015, Chapter VII,244-248.

1.3%, respectively (Table 2). Furthermore, we calculated LDP caused by different tumors in eastern, central and western regions of China (Table 2).

In order to compare LDP in 2014 with that in 2004, we calculated LDP caused by malignant tumours, lung cancer, gastric cancer, liver cancer, esophageal cancer, colorectal and anal cancer in China in 2004 was 18.7%,4.5%, 3.6%, 3.3%, 2.3%, 1.1%, respectively (shown in table 3). Furthermore, we also calculated LDP caused by different tumors in eastern, central and western regions (shown in Table 3).

Discussion

To the best of our knowledge, this was the first epidemiological study comparing LDP caused by malignant tumors in different regions of China. The top 5 cancer sites were similar in eastern, central and western regions, which were lung, liver, stomach, esophagus and colorectum. LDP caused by malignant tumors decreased in all three regions, but some differences were observed with respect to a specific cancer. LDPs caused by esophageal cancer and colorectal cancer were higher in western region than central and east regions. LDP caused by liver cancer was slightly higher in central region than in east and west regions. This finding may be due to the differences in lifestyles, geographical locations and living environment, economic level, medical resource allocation, diagnosis, and treatment level (Jemal et al., 2010; Zeng et al., 2015). The eastern region is well-developed region with a high standard of living and a preference Western

lifestyle. In recent years, the obesity rate in the eastern region is on the rise (Zheng et al., 2018; Yang et al., 2017). The potential factors linking obesity to cancer might cause insulin resistance, a chronic, subclinical inflammation in the visceral fat, and alterations on the tumor microenvironment driving tumor progression via the stimulation of cell survival/anti-apoptosis, cell proliferation, angiogenesis, and invasion/metastasis of cancer cells (Ungefroren et al., 2015). Higher LDP caused by liver cancer in central region may be related to its humid local climate and the consumption of mildew food by people living there.

Higher LDP in 2014 (19.21%) than that in 2004 (18.73%) attracted public attention. LDPs caused by lung cancer and colorectal cancer have increased in the past decade, while LDPs caused by gastric cancer, liver cancer, and esophageal cancer have experienced a decreasing trend. Strengthening physical activity, maintaining healthy weight, promoting healthy eating patterns, reducing meat food, increasing the intake of fruits and vegetables, stopping smoking, limiting alcohol consumption, and carrying out cancer screening are considered as effective measures for preventing and controlling malignant tumors.

In our daily life, we need an indicator to measure the risk of death caused by cancers. LDP is just a good indicator, which refers to the probability of death for a particular person from a certain death cause in the presence of various death causes. It is based on the principle of probability addition, but not affected by population composition and considering the risk of death competition. Cumulative mortality or cumulative risk

Table 3. 2004 Main Death Caused by Different Malignant Tumors on Surveillance Sites in China

Name of tumor	Whole area		Eastern area		Middle area		Western area	
	Mortality (1/million)	death probability(%)	Mortality (1/million)	death probability(%)	Mortality (1/million)	death probability(%)	Mortality (1/million)	death probability(%)
All malignant tumor	135.88	18.73	154.69	20.24	135.85	19.26	111.39	15.81
Lung cancer	30.83	4.47	37.85	5.17	30.79	4.53	21.76	3.34
Stomach Cancer	24.71	3.62	26.71	3.67	25.17	3.85	21.53	3.26
Liver Cancer	26.26	3.25	28.37	3.32	26.82	3.45	22.83	2.91
Esophageal cancer	15.21	2.25	16.67	2.29	15.52	2.42	12.92	1.98
Colorectal and anal cancer	7.25	1.11	8.67	1.24	7.19	1.08	6.07	0.95

Note: the age-specific mortality is cited by reference [4], 2008, Chapter VII, P52-53.

(Andersen et al., 2012; Kim, 2007; Latouche et al., 2013) is another indicator that can indicate the seriousness of a certain death cause, but it does not take into account the competition risks. On the other hand, in the analysis of time event data, there is a competitive risk. Some subjects may experience competition risks when the events of interest are excluded by different types of events that had occurred previously (Kohl, 2015). As it can be seen from Table 2, the mortality (26.40/10 million) in the eastern area was higher than that (24.14/10 million) of stomach cancer, but LDP caused by liver cancer (2.75%) was lower than that caused by gastric cancer (3.06%). The main reason for this finding might be as follows: the mortality of liver cancer in eastern area (13.96/10 million) was twice than stomach cancer (4.40/10 million) among sufferers aged less than 40 to 45 years old; however, the mortality of stomach cancer (124.55/10 million) was higher than that of liver cancer (100.65/10 million) among patients aged older than 70 to 75 years old, indicating that people died from liver cancer were younger, but people died from gastric cancer were older. Therefore, considering the competitive risk death, it can be seen that LDP caused by liver cancer was lower than that caused by gastric cancer.

The current investigation; however, was confronted with a number of limitations. The monitoring points for mortality by age in 2004 and 2014 were different (213 in 2004 and 605 in 2014), which may lead to differences in age specific mortality. Nevertheless, the National Disease Surveillance System was led by the National Health and Family Planning Commission in 2013 to integrate the death statistics system of the Ministry of Health and the National Disease Surveillance System. Death rate by age in 2014 was a continuation of the work of the Ministry of Health's death statistics system in 2004, with the same criteria for all disease classifications, working methods, and regional divisions, increasing the comparability of 2004 and 2014.

In conclusion malignant tumor is still the main cause of death among humans, giving rise to LDP. LDP caused by malignant tumours has two divisions. First, traditional upper digestive system cancers related to long-term chronic infection, such as esophageal cancer, gastric cancer, and liver cancer, which has shown a significant downward trend. Second, lung and colorectal cancers related to the environmental factors and lifestyle, which are on the rise. Therefore, cancer prevention and treatment strategies should be implemented to improve people's health in China. These strategies can be provision of health education, promotion of healthy lifestyles such as having healthy diet and moderate exercise, changing bad living habits, controlling environmental risk factors, and establishing environmental health monitoring systems.

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Authors' contributions

Conception and design: YUAN Ping

Acquisition of data (acquired and managed patients, provided facilities, etc.): CHEN Tie-hui

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Writing, review, and/or revision of the manuscript: YUAN Ping

Disclosure of potential conflicts of interest

The authors disclose no potential conflicts of interest.

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