

Original Article

Cancer incidence and patient survival rates among the residents in the Pudong New Area of Shanghai between 2002 and 2006

Xiao-Pan Li¹, Guang-Wen Cao², Qiao Sun¹, Chen Yang¹, Bei Yan¹, Mei-Yu Zhang¹, Yi-Fei Fu¹ and Li-Ming Yang¹

Abstract

With the growing threat of malignancy to health, it is necessary to analyze cancer incidence and patient survival rates among the residents in Pudong New Area of Shanghai to formulate better cancer prevention strategies. A total of 43,613 cancer patients diagnosed between 2002 and 2006 were recruited from the Pudong New Area Cancer Registry. The incidence, observed survival rate, and relative survival rate of patients grouped by sex, age, geographic area, and TNM stage were calculated using the Kaplan-Meier, life table, and Ederer II methods, respectively. Between 2002 and 2006, cancer incidence in Pudong New Area was 349.99 per 100,000 person-years, and the 10 most frequently diseased sites were the lung, stomach, colon and rectum, liver, breast, esophagus, pancreas, brain and central nervous system, thyroid, and bladder. For patients with cancers of the colon and rectum, breast, thyroid, brain and central nervous system, and bladder, the 5-year relative survival rate was greater than 40%, whereas patients with cancers of the liver and pancreas had a 5-year relative survival rate of less than 10%. The 1-year to 5-year survival rates for patients grouped by sex, age, geographic area, and TNM stage differed significantly (all $P < 0.001$). Our results indicate that cancer incidence and patient survival in Pudong New Area vary by tumor type, sex, age, geographic area, and TNM stage.

Key words Cancer, survival analysis, observed survival rate, relative survival rate

With the intensification of environmental change and an aging population, cancer has gradually become the primary cause of death for urban residents in China^[1]. Pudong New Area, the forerunner of China's urbanization and new rural construction process, has undergone tremendous changes in the past 20 years. Cancer has been ranked as the second leading cause of death in the district since 1993^[2,3]. To date, there have been no studies to appropriately detect the impact of changes in the living environment on cancer incidence and patient survival for those in urban China. Having undergone changes representative of those occurring country wide, Pudong New Area is a useful model with which to analyze these effects.

In the current study, we selected 43,613 cancer patients among the residents in the Pudong New Area of Shanghai diagnosed between 2002 and 2006, and we analyzed cancer incidence and patient survival among groups based on sex, age, geographic area,

and TNM stage. We report here that the elderly men living in urban areas were more susceptible to cancer and the elderly men living in rural areas with liver cancer or pancreatic cancer maybe got a poor prognosis. These findings suggest that the cancer prevention strategies should be based on sex, age, tumor type, and tumor pathologic stage in Pudong New Area or other place in China.

Patients and Methods

Study patients

We collected information about patients diagnosed with cancer between 2002 and 2006 among the residents of Pudong New Area from the Pudong New Area Cancer Registry^[4,5]. Population data were provided by the Statistics Bureau and the Public Security Bureau of Pudong New Area.

Follow-up after first diagnosis

Clinical and histopathologic data, including household register and TNM stage at the time of surgical treatment, were obtained from the Pudong New Area Cancer Registry. Patients who gave informed consent and accepted the community doctors' survey were followed. Follow-up entailed household survey was conducted by telephone

Authors' Affiliations: ¹Department of Tumors and Injury Prevention, Center for Disease Control and Prevention, Pudong New Area, Shanghai 200136, P. R. China; ²Department of Epidemiology, Second Military Medical University, Shanghai 200433, P. R. China.

Corresponding Author: Qiao Sun, Center for Disease Control and Prevention, Pudong New Area, 3039 Zhangyang Road, Shanghai 200136, P. R. China. Tel: +86-21-50342462; Fax: +86-21-38714688. Email: sunqiao163@hotmail.com.

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calls every year according to our standard epidemiologic procedure. The survival information of patients lost to follow-up was obtained from the coroner's registrar.

Statistical analyses

Cancer incidence for the resident household population was calculated based on the annual average population in Pudong New Area. Overall survival was analyzed using the Kaplan-Meier method. The observed survival rate (OSR) was analyzed with the life table method, the expected survival rate (ESR) was analyzed with the Ederer II method, and the relative survival rate (RSR) was equal to OSR divided by ESR^[6]. The log-rank test was used to compare survival curves. All statistical analyses were two-sided and performed using the Statistical Package for the Social Sciences software version 16.0 (SPSS, Inc., Chicago, IL). Statistical significance was set at $P < 0.05$.

Results

Survival of the whole population

We collected information about 43,163 patients with cancer in Pudong New Area. The median patient age was 68. In total, 42,484 patients were followed up and the remaining 1,129 patients were lost to follow-up. As of January 1, 2012, 30,194 patients who were followed up had died, and 12,290 were still alive.

Between 2002 and 2006, permanent residents collectively survived 12,461,038 person-years, with a rate of 6,240,355 person-years for males and 6,220,683 person-years for females. The incidence was 349.99 per 100,000 person-years, and the 10 most frequently diseased sites were the lung, stomach, colon and rectum, liver, breast, esophagus, pancreas, brain and central nervous system, thyroid, and bladder. The median survival (in days) of patients with cancer of these sites was 233 (lung), 415 (stomach), 1,332 (colon and rectum), 126 (liver), 3,685 (breast), 270 (esophagus), 119 (pancreas), 2,549 (brain and central nervous system), 3,645 (thyroid), and 2,829 (bladder). At 1, 2, 3, 4, and 5 years for all cancer patients, the OSR was 45.53%, 39.99%, 36.83%, 34.54%, and 32.72%, respectively, and the RSR was 48.92%, 44.89%, 43.95%, 43.38%, and 42.62%, respectively (data not shown in Tables or Figures). Cancers with a 5-year RSR greater than 40% occurred in the colon and rectum, breast, thyroid, brain and central nervous system, and bladder. In contrast, cancers of the liver and pancreas had a 5-year RSR less than 10%. The top 5 cancers in Pudong New Area occurred in the lung, stomach, colon and rectum, liver, and breast; the 5-year OSR was 8.53%, 25.87%, 42.69%, 7.07%, and 75.77%, respectively, and the 5-year RSR was 12.37%, 35.24%, 58.26%, 9.24%, and 86.13%, respectively (Table 1).

Survival of different groups

Between 2002 and 2006, the cancer incidence ratio in males to females was 1.22:1. More specifically, the incidence in males was

383.92 per 100,000 person-years, which was higher than that in females (315.96 per 100,000 person-years). Cancer incidence in the Pudong New Area was the highest in the elderly population. Patients aged 65 to 74 years accounted for 26.72% (11,652 of 43,613) of cases, and patients aged 75 and older accounted for 27.42% (11,959 of 43,613) of cases. The age-specific incidence was 1,176.80 per 100,000 person-years for patients aged 65 to 74 years and 1,760.22 per 100,000 person-years for patients aged 75 and older.

The survival rates for patients who were females, were urban residents, had tumors of low TNM stage, or were in low age groups were significantly higher than those for patients who were males, were rural residents, had tumors of high TNM stage, or were in high age groups, respectively (all $P < 0.001$; Figures 1Aa–d and Table 2).

Patient survival for cancers of the three most frequently diseased sites

Lung cancer

Among the patients with lung cancer diagnosed between 2002 and 2006, 5,698 were males, with a median age of 68 years, and 2,286 were females, with a median age of 68 years. The crude incidence was 64.01 per 100,000 person-years. The crude incidence for males was 91.31 per 100,000 person-years, which was significantly higher than that for females (36.75 per 100,000 person-years) ($U = 4.82$, $P < 0.01$). Lung cancer incidence in Pudong New Area peaked in the elderly population, with patients aged 65 to 74 years accounting for 34.67% (2,768 of 7,984) of cases and patients aged 75 and older accounting for 33.64% (2,686 of 7,984) of cases. The age-specific incidence was 279.56 per 100,000 person-years for patients aged 65 to 74 years and 395.35 per 100,000 person-years for patients aged 75 and older.

The 1-, 3-, and 5-year OSR of patients with lung cancer was 19.11%, 11.07%, and 8.53%, respectively, and the RSR was 20.67%, 13.66%, and 12.37%, respectively. The survival of patients who were females, were urban residents, had tumors of low TNM stage, or were in low age groups was significantly higher than that for patients who were males, were rural residents, had tumors of high TNM stage, or were in high age groups, respectively (all $P < 0.001$; Figures 1Ba–d and Table 3).

Gastric cancer

Between 2002 and 2006, 3,298 patients with gastric cancer were males, with a median age of 66 years, whereas 1,932 were females, with a median age of 66 years. The crude incidence was 41.97 per 100,000 person-years. Like for lung cancer, the crude incidence of gastric cancer in males was significantly higher than that in females (52.85 per 100,000 person-years for males vs. 31.06 per 100,000 person-years for females; $U = 2.37$, $P < 0.01$). Furthermore, in Pudong New Area, gastric cancer incidence was the highest among the elderly, with 29.77% (1,557 of 5,230) of cases occurring in patients aged 65 to 74 years and 30.82% (1,612 of 5,230) of cases occurring in patients aged 75 years and older. As for the patients aged 65 and 74 years, the age-specific incidence was 157.25 per 100,000 person-years; but for the patients aged 75 years and older,

Table 1. Patient survival of the top 10 cancers in Pudong New Area, 2002–2006

Rank	Cancer site(s)	Number of cases	Incidence (per 100,000 person-years)	Median survival (days)	1-year		2-year		3-year		4-year		5-year	
					OSR (%)	RSR (%)	OSR (%)	RSR (%)	OSR (%)	RSR (%)	OSR (%)	RSR (%)	OSR (%)	RSR (%)
1	Lung	7,984	64.07	233	19.11	20.67	13.68	15.63	11.07	13.66	9.47	12.85	8.53	12.37
2	Stomach	5,230	41.97	415	39.43	42.63	32.93	37.39	29.58	35.97	27.55	35.43	25.87	35.24
3	Colon, rectum	4,874	39.11	1,332	61.16	66.04	53.53	60.76	48.50	59.05	45.26	59.01	42.69	58.26
4	Liver	4,019	32.25	126	17.04	18.13	12.66	13.94	10.30	11.91	8.61	10.55	7.07	9.24
5	Breast	3,215	25.80	3,685	89.89	92.52	85.04	89.33	81.03	87.57	78.41	87.22	75.77	86.13
6	Esophagus	1,608	12.90	270	24.00	26.48	17.29	20.26	14.74	18.80	13.00	18.39	12.10	18.22
7	Pancreas	1,540	12.36	119	7.14	7.92	5.32	6.26	4.68	5.97	3.96	5.58	3.81	5.81
8	Brain, central nervous system	1,408	11.30	2,549	63.00	65.71	58.66	63.01	56.25	62.95	54.12	62.63	52.04	62.32
9	Thyroid	1,170	9.39	3,645	93.42	95.26	92.22	95.22	91.03	95.15	89.32	94.89	87.86	94.63
10	Bladder	1,130	9.07	2,829	71.86	79.59	64.96	76.18	60.97	75.46	57.52	75.04	54.69	74.32

OSR, observed survival rate; RSR, relative survival rate.

Table 2. Patient survival of the top 10 cancers in Pudong New Area, 2002–2006

Feature		Number of cases	Incidence (per 100,000 person-years)	Median survival (days)	1-year		3-year		5-year	
					OSR (%)	RSR (%)	OSR (%)	RSR (%)	OSR (%)	RSR (%)
Sex	Male	23,958	383.92	374	37.70	40.56	28.61	35.43	24.51	35.14
	Female	19,655	315.96	1,084	55.07	59.32	46.85	54.51	42.73	53.79
Age	35–44	2,938	140.02	3,685	68.21	68.30	61.98	62.45	59.31	60.43
	45–54	7,949	316.47	2,330	62.15	62.34	54.18	55.16	50.48	52.78
	55–64	7,714	569.22	859	52.70	53.05	43.83	45.61	39.55	43.69
	65–74	11,652	1,176.80	421	40.20	41.05	30.58	34.62	25.89	34.21
Geographic area	Rural	6,005	317.05	360	38.02	40.88	30.56	36.38	27.03	35.54
	Urban	18,605	414.90	672	48.72	52.39	39.40	46.90	35.08	46.72
	Town	19,003	312.41	519	44.77	48.14	36.29	43.20	32.20	42.72
TNM stage	I+II	8,967	–	3,685	80.63	86.70	71.45	85.06	66.43	84.26
	III+IV	9,707	–	295	29.36	31.57	19.42	23.12	15.70	21.81
	Unknown	24,939	–	371	39.19	42.14	31.15	37.08	27.22	36.81

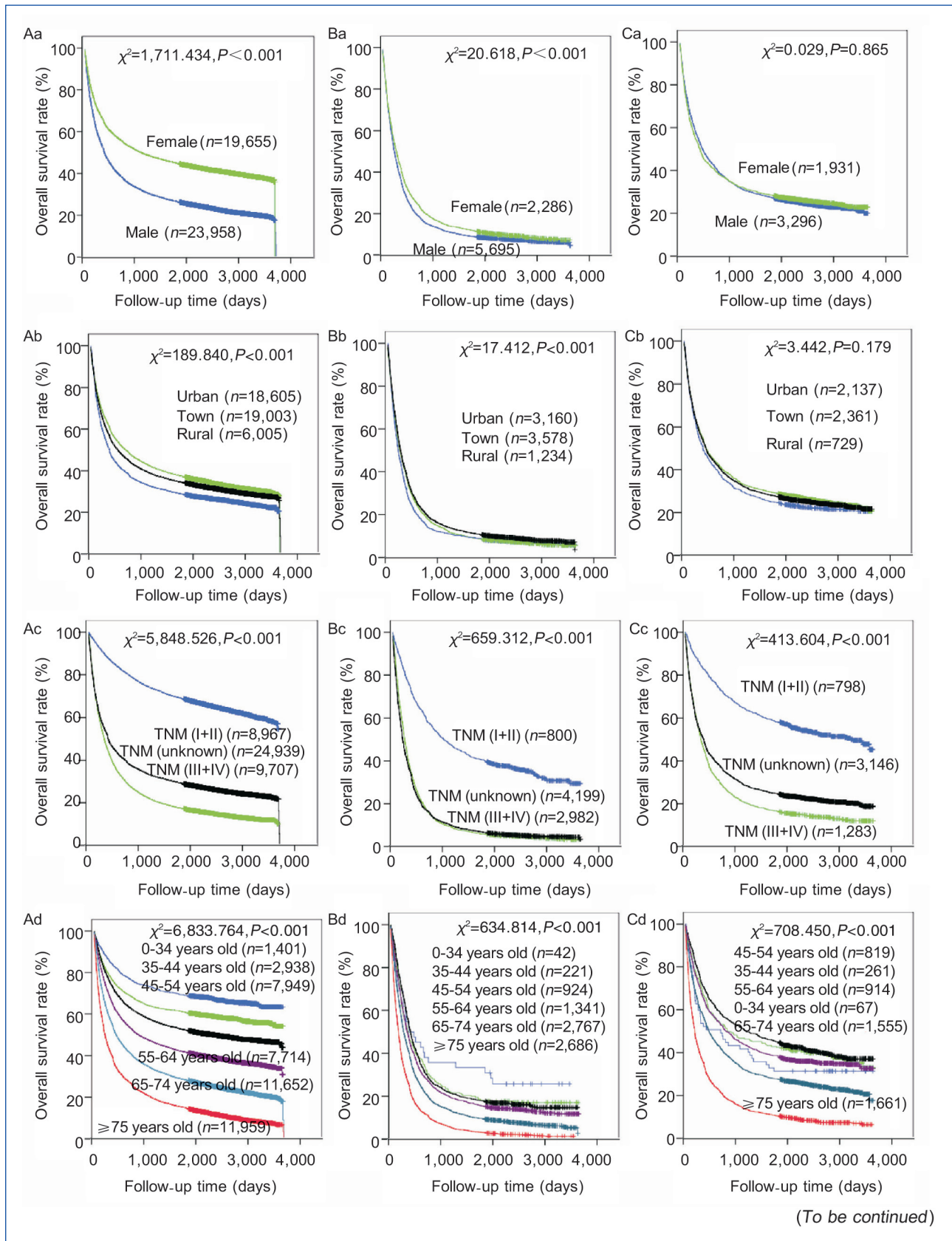
TNM stage, tumor-lymph node-metastasis classification; –, data not shown. Other footnotes as in Table 1.

the age-specific incidence was 237.27 per 100,000 person-years.

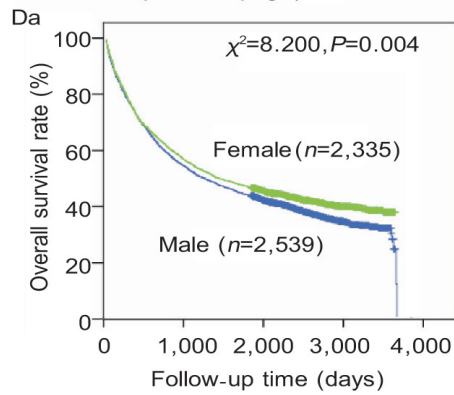
The OSR at 1, 3, and 5 years for gastric cancer patients was 39.43%, 29.58%, and 25.87%, respectively, and the RSR at those years was 42.63%, 35.97%, and 35.24%, respectively. The survival of patients with tumors of low TNM stage or patients in low age groups was significantly higher than that of patients with tumors of high TNM stage or patients in high age groups ($\chi^2 = 708.450$ and 413.604 , respectively; $P < 0.001$). There was no significant difference in survival based on sex or geographic area ($\chi^2 = 0.029$ and 3.442 , $P = 0.865$ and 0.179 , respectively; **Figures 1Ca–d** and **Table 4**).

Colorectal cancer

Among the patients diagnosed with colorectal cancer between 2002 and 2006, 2,539 were males, with a median age of 66, and 2,335 were females, with a median age of 66. The crude incidence was 39.11 per 100,000 person-years. For males, this rate was 40.69 per 100,000 person-years and was higher than that in females (37.54 per 100,000 person-years). However, this difference was not significant ($U = 0.356$, $P > 0.05$). As observed for colorectal cancer, lung cancer and gastric cancer, colorectal cancer incidence in Pudong New Area was the highest for individuals aged 65 years and older. Indeed, patients aged 65 to 74 years old accounted for 31.23% (1,522 of 4,874) of



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The labels for each panel

	All cancers	Lung cancer	Gastric cancer	Colorectal cancer
Sex	Aa	Ba	Ca	Da
Geographic area	Ab	Bb	Cb	Db
TNM stage	Ac	Bc	Cc	Dc
Age	Ad	Bd	Cd	Dd

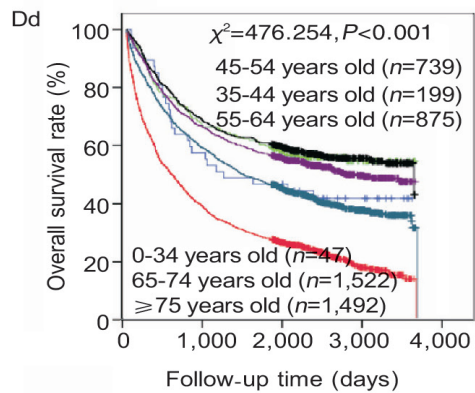
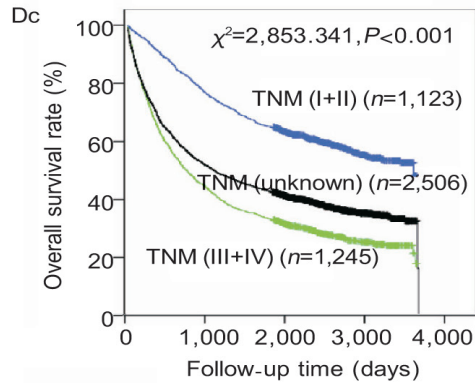
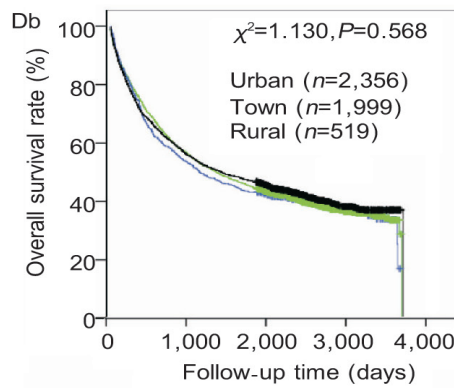


Figure 1. Survival of cancer patients among the residents in the Pudong New Area of Shanghai between 2002 and 2006. The curves show the survival of patients with all cancers (A), lung cancer (B), gastric cancer (C), and colorectal cancer (D) as grouped by sex (a), geographic area (b), TNM stage (c), and age (d).

cases, and patients aged 75 years and older accounted for 30.61% (1,492 of 4,874) of cases. The age-specific incidence was 153.71 per 100,000 person-years for patients aged 65 to 74 years and 219.60 per 100,000 person-years for patients aged 75 years and older.

The 1-, 3-, and 5-year OSR of colorectal cancer patients was 61.16%, 48.5%, and 42.69%, respectively, and the corresponding RSRs were 66.04%, 59.05%, and 58.26%, respectively. The survival of patients who were females or had tumors of low TNM stage was significantly higher than that for patients who were males or had tumors of high TNM stage, respectively ($P = 0.004$ and $P < 0.001$,

respectively). There was no significant difference in survival by geographic area ($P = 0.568$; **Figures 1Da–d** and **Table 5**).

Discussion

Here, we report that patients diagnosed with cancer between 2002 and 2006 in Pudong New Area had a 5-year RSR of 42.62%. This rate was 35.14% for males and 53.79% for females, both of which were higher than that of Cixian county^[7] and Nanhui district of Shanghai^[8]. Additionally, the 5-year RSR for lung cancer patients in Pudong New Area was lower than that for patients in

Table 3. Survival of lung cancer patients in Pudong New Area from 2002 to 2006 by sex, age, geographic area, and TNM stage

Feature		Number of cases	Incidence (per 100,000 person-years)	Median survival (days)	1-year		3-year		5-year	
					OSR (%)	RSR (%)	OSR (%)	RSR (%)	OSR (%)	RSR (%)
Sex	Male	5,698	91.31	224	17.73	19.14	10.18	12.98	7.92	12.02
	Female	2,286	36.75	266	22.57	24.91	13.30	16.33	10.05	14.51
Age	35–44	221	10.53	333	30.32	30.36	20.36	20.52	17.65	17.99
	45–54	924	36.79	382	28.35	28.44	19.26	19.61	16.77	17.55
	55–64	1,341	98.95	316	26.92	27.11	17.38	18.11	14.20	15.74
	65–74	2,768	279.56	248	19.48	19.88	11.02	12.48	8.20	11.16
Geographic area	Rural	1,235	65.21	198	15.32	16.65	9.97	12.31	7.58	11.48
	Urban	3,161	70.49	233	19.15	20.82	10.22	12.62	7.77	11.77
	Town	3,588	58.99	243	20.41	22.18	12.21	15.07	9.53	14.44
TNM stage	I+II	800	–	983	57.00	61.96	42.88	52.94	37.47	52.77
	III+IV	2,982	–	230	14.76	16.04	7.11	8.78	4.99	7.56
	Unknown	4,202	–	190	15.00	16.30	7.84	9.68	5.55	8.41

Footnotes as in Table 2.

Table 4. Survival of gastric cancer patients in Pudong New Area from 2002 to 2006 by sex, age, geographic area, and TNM stage

Feature		Number of cases	Incidence (per 100,000 person-years)	Median survival (days)	1-year		3-year		5-year	
					OSR (%)	RSR (%)	OSR (%)	RSR (%)	OSR (%)	RSR (%)
Sex	Male	3,298	52.85	436	39.90	42.86	29.16	36.22	25.40	35.95
	Female	1,932	31.06	385	38.68	42.50	30.35	36.77	26.71	34.55
Age	35–44	261	12.44	816	53.26	53.33	45.21	45.55	40.83	41.61
	45–54	819	32.61	1,180	56.78	56.95	47.25	48.10	42.48	44.42
	55–64	914	67.44	782	52.08	52.43	40.15	41.79	36.12	39.91
	65–74	1,557	157.25	454	40.39	41.18	29.58	33.46	26.00	35.37
Geographic area	Rural	729	38.49	360	36.49	39.24	26.75	32.62	23.01	32.35
	Urban	2,138	47.68	428	40.57	43.62	30.79	37.55	27.24	36.48
	Town	2,363	38.85	420	39.35	42.31	29.39	35.84	25.55	34.03
TNM stage	I+II	798	–	3,243	72.18	77.61	60.90	74.27	54.86	73.51
	III+IV	1,283	–	300	28.14	30.26	18.16	22.15	14.85	21.52
	Unknown	3,149	–	360	35.76	38.45	26.32	32.10	23.03	31.38

Footnotes as in Table 2.

Table 5. Survival of colorectal cancer patients in Pudong New Area from 2002 to 2006 by sex, age, geographic area, and TNM stage

Feature		Number of cases	Incidence (per 100,000 person-years)	Median survival (days)	1-year		3-year		5-year	
					OSR (%)	RSR (%)	OSR (%)	RSR (%)	OSR (%)	RSR (%)
Sex	Male	2,539	40.69	1,241	60.03	64.90	47.30	59.36	41.00	58.95
	Female	2,335	37.54	1,429	62.36	67.41	49.76	59.29	44.47	57.43
Age	35-44	199	9.48	3,685	73.37	73.46	62.81	63.29	55.92	57.00
	45-54	739	29.42	3,624	73.21	73.43	62.79	63.95	58.01	60.72
	55-64	875	64.57	2,911	70.51	70.98	59.77	62.22	54.39	60.14
	65-74	1,522	153.71	1,477	64.37	65.73	50.23	56.91	43.45	59.22
Geographic area	Rural	519	27.40	1,117	58.38	62.77	46.05	56.16	41.45	56.07
	Urban	2,356	52.54	1,326	61.74	66.39	48.41	59.04	42.01	58.88
	Town	1,999	32.86	1,395	61.16	65.76	49.20	60.00	43.75	59.41
TNM stage	I+II	1,123	-	3,601	82.72	88.95	68.83	83.94	62.20	81.14
	III+IV	1,245	-	741	50.28	54.06	36.14	44.07	30.31	43.93
	Unknown	2,506	-	1,085	56.85	61.13	45.47	55.45	40.03	54.01

Footnotes as in Table 2.

the five countries in central Europe^[9]. The 5-year RSR may vary with socioeconomic conditions, suggesting that cancer prevention and control strategies should be tailored to each distinct set of socioeconomic conditions. To improve the quality of life and overall survival of cancer patients in China, medical care for cancer patients should be strengthened in key areas, such as rural areas.

As the body's carcinogenic risk factors accumulated and its recovery level decreases, cancer incidence increases^[10]. Therefore, the high incidence we observed is a corroboration of an aging population in Pudong New Area^[11]. It reminds us that some effective measures must be taken to prevent the elderly people suffering from cancer.

We found that the 5-year survival rate of patients in Pudong New Area who have tumors of early TNM stage is much higher than that of patients with tumors of advanced stage. This suggests that screening for early diagnosis is an effective method to improve the survival of cancer patients. Moreover, China has a high incidence and mortality of gastric cancer worldwide. The early symptoms of this disease are highly intricate and often misdiagnosed, resulting in patients ultimately being diagnosed with late-stage gastric cancer and experiencing a very high mortality^[12]. Although the 5-year OSR of patients with late-stage gastric cancer in Pudong New Area was 14.85%, which is much higher than that of patients with stage IV gastric cancer in the study by Xue *et al.*^[13], it is far below the OSR of patients with early-stage disease. Furthermore, in recent years, a lot of progress has been made in colorectal cancer screening^[14]. We observed that patients with early-stage disease had a higher survival rate than patients with late-stage disease, suggesting that colorectal cancer screening is necessary in the region.

The top 10 cancers in Pudong New Area differed from that of Shanghai or the nation. Colorectal cancer, prostate cancer, and

renal carcinoma ranked second, seventh, and tenth, respectively, in Shanghai, whereas bladder cancer ranked eighth and thyroid cancer ranked out of the top 10, and the last three of top ten cancers in China were bladder cancer, brain cancer and lymphoma from 2003 to 2007^[15]. In addition, the top 10 cancers in males and females in Pudong New Area and in the world differed from each other. Unlike in Pudong New Area, the top 10 cancers in the world included non-Hodgkin's lymphoma and cancers of the oral cavity in males and cervical cancer and uterine cancer in females^[12]. The reason for this difference may be associated with the district's geographic location and population structure.

Although our study provides novel insight into cancer incidence and patient survival in Pudong New Area, it has several limitations. First, the study subjects were permanent residents, who make up only one component of the resident population in the district. As Pudong has frequent and unstable population exchange, it is possible that we have overestimated the incidence of cancer by focusing solely on permanent residents. Second, because the information of tumor recurrence or metastasis was difficult to obtain, the disease-free survival could not be calculated, therefore, it is difficult to estimate the patient's quality of life.

In summary, the current study demonstrated that tumor type, sex, age, geographic location, and TNM stage are associated with poor prognosis in patients with cancer. Additional work is needed to determine how to improve the survival of cancer patients.

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