Original Article

An analysis of melanoma epidemic characteristics and distribution in the eastern Chinese city Ningbo from 2011 to 2018

Moucheng Zhang[1,2#]^, Jiyun Zhu[1#], Liangqi Guo[3], Kaijun Gao[3], Huaxin Ding[4], Ling Tang[5], Zhilong Yan[1]

[1]Department of Gastrointestinal Surgery, Ningbo First Hospital, Ningbo, China; [2]Second Clinical Medical College of Southern Medical University, Guangzhou, China; [3]Medical School of Ningbo University, Ningbo, China; [4]Ningbo Clinicopathological Diagnosis Center, Ningbo, China; [5]Department of Science and Technology, Health Commission of Ningbo, Ningbo, China

Contributions: (I) Conception and design: M Zhang, Z Yan; (II) Administrative support: J Zhu; (III) Provision of study materials or patients: L Guo, K Gao; (IV) Collection and assembly of data: H Ding; (V) Data analysis and interpretation: L Tang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Zhilong Yan, MD. Department of Gastrointestinal Surgery, Ningbo First Hospital, No. 59 Liuting Road, Ningbo 315000, China. Email: yanzhilong@nbu.edu.cn.

Background: Melanoma is a malignant tumor with poor prognosis and increasing global incidence. Little is known about the burden of melanoma in eastern Chinese cities, as the results of previous studies are inconsistent or unclear.

Methods: In this study, we collected incidence rate data from the Ningbo National Health Information Platform, diagnostic data from the Ningbo Clinicopathological Diagnosis Center, and other relevant data from the Ningbo Bureau of Statistics to evaluate temporal trends and geographic variation in melanoma incidence and to analyze the relationship between melanoma incidence and medical resource availability.

Results: The incidence of melanoma in Ningbo has increased significantly in the past 8 years. In 2018, melanoma incidence in Ningbo was 521.67% higher than that in 2011, which was higher than the increase in the national rate. This may be a result of our study including early melanoma, which has a faster increase rate than invasive melanoma. The incidence rate of melanoma in urban areas was significantly higher than that in rural districts. From 2011 to 2018, the incidence rate in rural districts increased by 794.15%, which was significantly higher than the incidence rate increase in urban areas (245.03%).

Conclusions: All indicators relating to medical resources had a significant positive impact on melanoma incidence, indicating that the low incidence of melanoma is partly due to a lack of medical resources, which can lead to delayed treatment and increased disability-adjusted life years (DALYs). Therefore, it is necessary to continue to strengthen investment in medical resources, especially in China's rural areas and western regions where medical resources are less available.

Keywords: Ningbo City; melanoma; incidence; epidemiology; medical resources

Submitted Nov 29, 2021. Accepted for publication Apr 13, 2022.

doi: 10.21037/apm-21-3942

View this article at: https://dx.doi.org/10.21037/apm-21-3942

^ ORCID: 0000-0001-6564-4083.

Introduction

Melanoma is a malignant tumor with poor prognosis and increasing global incidence. Although the total incidence of melanoma is relatively low in China, the incidence rate has been increasing rapidly at a rate of 3–5% per year (1), with about 20,000 new cases diagnosed every year (2). The latest report, from 2017, shows that the age-standardized incidence of melanoma in China was 0.9 per 100,000. This is a 110.3% increase compared with the incidence rate in 1990 and is higher than the global increase (41.2%) during the same period (3). To date, epidemiological studies of melanoma in China are rare and are limited by insufficient research samples (4,5) or incomplete data from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) (3,6). Therefore, these data do not reflect the actual incidence rate of melanoma in China. Current Chinese epidemiological studies have also produced some contradictory results. In Europe and the United States, 90% of melanomas affecting the Caucasian population are skin melanomas associated with ultraviolet (UV) irradiation (7-9). However, for Chinese people, the most common type of melanoma is acral Melanoma, which accounts for 50% of cases, followed by mucous membrane melanoma, which accounts for 20–30% of cases (7,10,11). This kind of melanoma is found mostly among farmers (66%) (12), possibly due to trauma caused by repeated infection, especially in the lower limbs (13). Therefore, the melanoma incidence rate in rural areas should be higher than that in the city. However, Chinese epidemiological studies show that the rate of melanoma in urban areas is higher than that in rural areas. One study showed that melanoma rates in the eastern regions were significantly higher than those in the western provinces, yet the disability-adjusted life years (DALYs) were the opposite, with UV radiation difference cited as the reason for this discrepancy (3). As the vast majority of melanomas in China are limb and mucous types which are not obviously related to UV radiation, this explanation is not convincing.

The causes of melanoma are complex. For non-acral freckle-nevus cutaneous melanoma, excessive UV exposure is the clear cause. Intermittent intense sun exposure increases the risk of melanoma in the trunk and limbs, while chronic sun exposure increases the risk of melanoma in the head, neck and arms. The main UV spectrum causing melanoma is still unclear, and UV-B is traditionally considered to be the main cause of melanoma. Epidemiological studies (3-5) have found that UV-A also plays an important role in the occurrence of melanoma. UV-A is more likely to penetrate into the dermis than UV-B, but less genotoxicity. The process of inducing melanoma requires the participation of melanin. Unfortunately, UV exposure does not explain the occurrence of acral melanoma. Due to the limitation of epidemiological characteristics, there are few studies (7-10) on the etiology of acral freckle in European and American countries, and there is a lack of large-scale multi-center high-quality research data. It may be more affected by other non-UV carcinogenic mechanisms such as trauma and repeated rout of moles. Other risk factors for cutaneous melanoma include: male sex, a family history of melanoma, a large number of moles or dysplastic moles, immune deficiency, Fitzpatrick I skin, non-melanoma skin cancer, etc.

According to the current widely accepted classification methods, the pathological types of melanoma mainly include superficial diffuse type, nodular type, acral freckle type and malignant freckle type. The first two are the most common types of Eurasians. The most common subtype of melanoma in China is different from Caucasian race in Europe and America, which is a type of acral freckle, which tends to occur in the palm, soles of feet, under the nail and other places where there is less UV radiation. Acral cutaneous melanoma is more aggressive and has a worse prognosis than other subtypes. Studies (7-9) on prognostic factors of skin melanoma have guiding significance for patients' treatment options. For example, sentinel lymph node status is related to patients' overall survival. Therefore, National Comprehensive Cancer Network (NCCN) Melanoma Diagnosis and Treatment Guidelines (2018.v1) suggest that: Patients with sentinel lymph node metastasis larger than 1mm in diameter should be considered as a group with poor prognosis, and more effective adjuvant therapy, such as immunotherapy or molecular targeted therapy, should be given after surgery, and regional lymph node dissection or close follow-up should be considered to observe regional lymph node status. For patients with negative regional lymph nodes, immunotherapy or molecularly targeted drug therapy is not recommended, and regional lymph node dissection is not recommended. Therefore, the analysis of prognostic factors is indeed very important. At present, it is generally believed that tumor thickness and primary ulcer are the most important prognostic factors of melanoma. Regional lymph node metastasis was an independent risk factor for prognosis in stage III patients, while elevated lactate dehydrogenase (LDH) was an important predictor of survival outcome in stage IV patients. However, it is worth noting that melanoma of the skin has different epidemiological characteristics in different races. At present, there are many studies (7-9) on prognostic factors of melanoma of the skin, but most of them come from European and American countries, and their research results are not consistent with the epidemiological characteristics of China to some extent. Therefore, it is particularly important to study the prognostic factors of Chinese patients.

The present study addresses the lack of epidemiological studies (1-3) on the high incidence of melanoma in eastern China by investigating melanoma incidence in Ningbo, a large city in eastern China. We retrieved data from the Ningbo National Health Information Platform and the Clinicopathological Diagnosis Center, including outpatient data, hospitalization data, and pathological diagnosis information, and analyzed this data in relation to population data from the Ningbo City Bureau of Statistics and medical resource-related indicators. We then analyzed melanoma incidence, trends, and regional distribution differences and the reasons for these differences. Finally, we explored contributing factors to the disease burden of melanoma and made recommendations for evidence-based policies and disease prevention strategies. We present the following article in accordance with the STROBE reporting checklist (available at https://apm.amegroups.com/article/view/10.21037/apm-21-3942/rc).

Methods

Data sources

Incidence data were retrieved from the outpatient and inpatient data uploaded by the National Health Information Platform of Ningbo from 2011 to 2018, and pathological diagnosis information was retrieved from the Ningbo Clinicopathological Diagnosis Center from 2011 to 2018 (patient name, ID number, date of birth, address, diagnosis basis, diagnosis result, and reporting unit). Tumor classification and melanoma diagnosis were coded according to the 10th edition of the International Classification of Diseases (ICD), using the codes C43-C43.9, D03-D03.9, D22-D23.9, D48.5, and M87200-M87740. Demographic data from 2011 to 2018 were obtained from the Ningbo Municipal Bureau of Statistics, including male and female age groups, resident population, registered population data, and indicators of medical resources (the number of hospital beds, doctors, and licensed nurses, etc.).

Quality control of data

The Ningbo National Health Information Platform includes an electronic health file collaboration service, a diagnosis and treatment sharing subsystem, a health file sharing subsystem, a regional diagnosis and treatment reminder service, a unique resident identity authentication function, a regional image sharing subsystem, and an interface with other systems. The information platform monitors daily data uploading and downloading and provides timely feedback about improving the monitoring system to guarantee that the account checking pass-through rate exceeds 98%. The Ningbo Health Committee Health Information Center performs a monthly quality control review of the Ningbo National Health Information Platform. When the data is incomplete, misstatement notices are issued to the medical institutions to carry out a second verification, and these institutions commit to the timely correction, supplement, and track corrective, year-end of the monitoring data in at least 1 data cleaning, including logic verification and quality control. The Ningbo Clinicopathological Diagnosis Center consists of the Ningbo First Hospital, the Ningbo Second Hospital, the Ningbo Third Hospital, the Ningbo Medical Center Hospital, the Ningbo Women and Children's Hospital, and the Traditional Chinese Medicine Hospital, which is responsible for overseeing clinical and pathological diagnosis in the city. The study was approved by the Ethics Committee of Ningbo First Hospital (No. 2020-R187), and other hospitals were informed and agreed with the study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and informed consent was waived due to the retrospective nature of this study.

Statistical analysis

The database was established using Excel 2016 software (Microsoft, Redmond, WA, USA). The morbidity, age-specific morbidity, success rate, and cumulative morbidity of people aged 0–74 (CIR0-74Y) and the truncation rate of people aged 35–64 (TR35-64Y) were calculated per 100,000 people. SAS 9.3 software (SAS Institute, Cary, NC, USA) was used to calculate crude incidence and age-specific incidence. The age-standardized incidence rate by Chinese standard population (ASIRC) was calculated according to the population of China in the sixth cycle of 2010, and the age-standardized incidence rate by world standard population (ASIRW) was calculated using Segi's world population. Next, the distribution of melanoma pathological types in males and females, the distribution of melanoma treatment in different types of hospitals, and indicators of medical resources were calculated. Using the statistical software SPSS 22 (IBM Corp., Armonk, NY, USA), we assessed gender and geographic factors by *t*-test and compared different hospital types by chi-squared test. A variance test was used to compare the number and proportion of cases with the registered population. A two-factor analysis of variance (ANOVA) was used to compare the distribution of melanoma types from 2011 to 2018. Pearson correlation analysis and Ridge regression analysis were used to analyze morbidity and medical resources in each region. A correlation coefficient of 0.8 to 1.0 indicated a highly relevant correlation, 0.6 to 0.8 indicated a strong correlation, and 0.4 to 0.6 indicated a moderate correlation, while a P value of <0.05 was considered statistically significant.

Results

Melanoma incidence and temporal trends in Ningbo from 2011 to 2018

As shown in *Table 1*, the total number of melanoma cases in Ningbo from 2011 to 2018 was 1,047, including 543 males and 504 females, with a male-to-female incidence ratio of 1.17:1. The coarse incidence rate was 1.657 per 100,000, the ASIRC was 1.642 per 100,000, and the ASIRW was 1.454 per 100,000, with CIR0-74Y being 0.156% and TR35-64Y being 1.681 per 100,000. Among these data, the crude incidence rate and the ASIRC were highest in 2017, while the ASIRW and TR35-64Y peaked in 2015 and 2016, respectively. At the same time, CIR0-74Y increased year by year, with a peak of 0.237% in 2018. As shown in *Figure 1A* (melanoma cases), *Figure 1B* (crude incidence rate), *Figure 1C* (ASIRC), *Figure 1D* (ASIRW), *Figure 1E* (CIR0-74Y), and *Figure 1F* (TR35-64Y), the male and female standard incidence rate rose sharply between 2011 and 2015 and then remained relatively stable from 2015 to 2018. With regard to the overall trend from 2011 to 2018, the age-standardized incidence of melanoma in 2018 increased by 521.67% compared with that in 2011, which was higher than the national rate increase from 1990 to 2017 (110.3%) and much higher than the global rate increase from 1990 to 2017 (41.2%) (3). According to the cancer registration data (3), the crude incidence of melanoma in 2017 was 2.436 per 100,000, which was much higher than the highest incidence of melanoma in 2017 reported in the eastern Chinese regions (1.5 per 100,000). However, when the early melanoma (i.e., melanoma *in situ*) data was discounted, the crude incidence of melanoma in 2017 was 1.524 per 100,000, which was consistent with the reported incidence (*Table 2*).

Distribution of different pathological types of melanoma from 2011–2018

As shown in *Table 3*, 179 (17.1%) of the total 1,047 cases did not list the pathological type. The remaining cases predominantly involved the skin and mucous membrane, with 657 cases (62.75%) and 172 cases (16.43%), respectively. Melanomas of the skin and mucous membrane were slightly more common in women than in men, with 329 cases (64.26%) *vs.* 328 cases (61.31%), respectively, involving the skin and 87 cases (16.99%) *vs.* 85 cases (15.89%), respectively, involving the mucous membrane. Melanomas of the eye choroid and central nervous system were extremely rare, accounting for only 30 cases (2.87%) and 9 cases (0.86%), respectively. In terms of gender, these melanomas were slightly more common in men than in women, with 16 cases (2.99%) *vs.* 14 cases (2.73%), respectively, for eye choroid melanoma and 5 cases (0.93%) *vs.* 4 cases (0.78%), respectively, for central nervous system melanoma, but the chi-squared test showed no statistical difference (χ^2=2.721; P=0.606).

The distribution of melanoma in Ningbo districts from 2011 to 2018

Out of 1,047 cases, 56 cases (5.35%) were from regions outside Ningbo City, 89 cases (8.50%) were from regions outside Zhejiang province, and 43 cases (4.11%), were from a location unknown (*Table 4*). Yinzhou District in Ningbo had the largest number of melanoma cases during these years, averaging 20.92%, with a peak of 36.11% in 2011, which was higher than the average number of 16.52%. The differences in melanoma incidence between the different districts were statistically significant (χ^2=124.379; P=0.003). As shown in *Table 5*, the average number of cases in Yinzhou District during 2011 to 2018 was 27.38±10.31, and the occupancy rate was 27.68%±6.3%, which was higher than the average rate of the city as a whole (10.74±8.44 and 10%±7.35%). Cixi City had the lowest average rate, at 4.63±2.5 and 4.69%±2.43%. There were statistically significant differences in the number and proportion of cases in different regions (P<0.01). However, due to large population differences between the districts, the incidence

Table 1 Melanoma incidence in different gender populations in Ningbo from 2011 to 2018

Year	Gender	N	Population	Incidence (per 100,000)	ASIRC (per 100,000)	ASIRW (per 100,000)	CIR0-74Y (%)	TR35-64Y (per 100,000)
2011	Both	36	7,628,000	0.472	0.440	0.323	0.030	0.615
	Male	19	3,894,956	0.488	0.443	0.325	0.025	0.601
	Female	17	3,733,044	0.455	0.437	0.326	0.036	0.629
2012	Both	53	7,639,000	0.694	0.694	0.617	0.070	0.726
	Male	26	3,900,573	0.667	0.663	0.583	0.074	0.709
	Female	27	3,738,427	0.722	0.720	0.657	0.066	0.743
2013	Both	90	7,663,000	1.174	1.170	0.987	0.126	1.419
	Male	47	3,912,828	1.201	1.182	1.024	0.129	1.196
	Female	43	3,750,172	1.147	1.148	0.954	0.122	1.652
2014	Both	113	7,811,000	1.447	1.463	1.436	0.130	1.556
	Male	61	3,988,398	1.529	1.479	1.332	0.120	1.867
	Female	52	3,822,602	1.360	1.440	1.561	0.142	1.229
2015	Both	183	7,825,000	2.339	2.375	2.234	0.224	2.506
	Male	103	3,995,547	2.578	2.525	2.248	0.230	2.556
	Female	80	3,829,453	2.089	2.195	2.279	0.219	2.454
2016	Both	186	7,875,000	2.362	2.305	2.022	0.206	2.869
	Male	91	4,021,078	2.263	2.211	2.074	0.191	2.434
	Female	95	3,853,922	2.465	2.403	1.974	0.221	3.326
2017	Both	195	8,005,000	2.436	2.377	2.008	0.220	2.450
	Male	99	4,087,457	2.422	2.367	2.142	0.222	1.978
	Female	96	3,917,543	2.451	2.385	1.882	0.217	2.944
2018	Both	191	8,202,000	2.329	2.314	2.002	0.237	2.469
	Male	97	4,188,048	2.316	2.252	2.045	0.224	2.438
	Female	94	4,013,952	2.342	2.383	1.990	0.252	2.501
Total	Both	1,047	62,648,000	1.657±0.813	1.642±0.808	1.454±0.731	0.156±0.078	1.826±0.868
	Male	543	31,988,886	1.683±0.828	1.64±0.814	1.472±0.762	0.152±0.077	1.722±0.789
	Female	504	30,659,114	1.629±0.81	1.639±0.808	1.453±0.716	0.159±0.08	1.935±1.017

ASIRC, the age-standardized incidence rate by Chinese standard population; ASIRW, the age-standardized incidence rate by world standard population; CIR0-74Y, the cumulative morbidity of people aged 0–74; TR35-64Y, the truncation rate of people aged 35–64.

rate was calculated by the population of each area, as shown in *Table 5*. The incidence of melanoma in Yinzhou District was 2.672±1.056 (per 100,000), and the incidence of melanoma in Ningbo City was 2.26±1.75 (per 100,000). The highest incidence was in Zhenhai District, with 4.56±2.19 (per 100,000). There were statistical differences in the incidence among different districts in Ningbo (χ^2=124.379; P=0.003).

Reasons for the different distribution of melanoma in different districts of Ningbo

The above results indicated obvious differences in melanoma incidence between urban and rural regions of

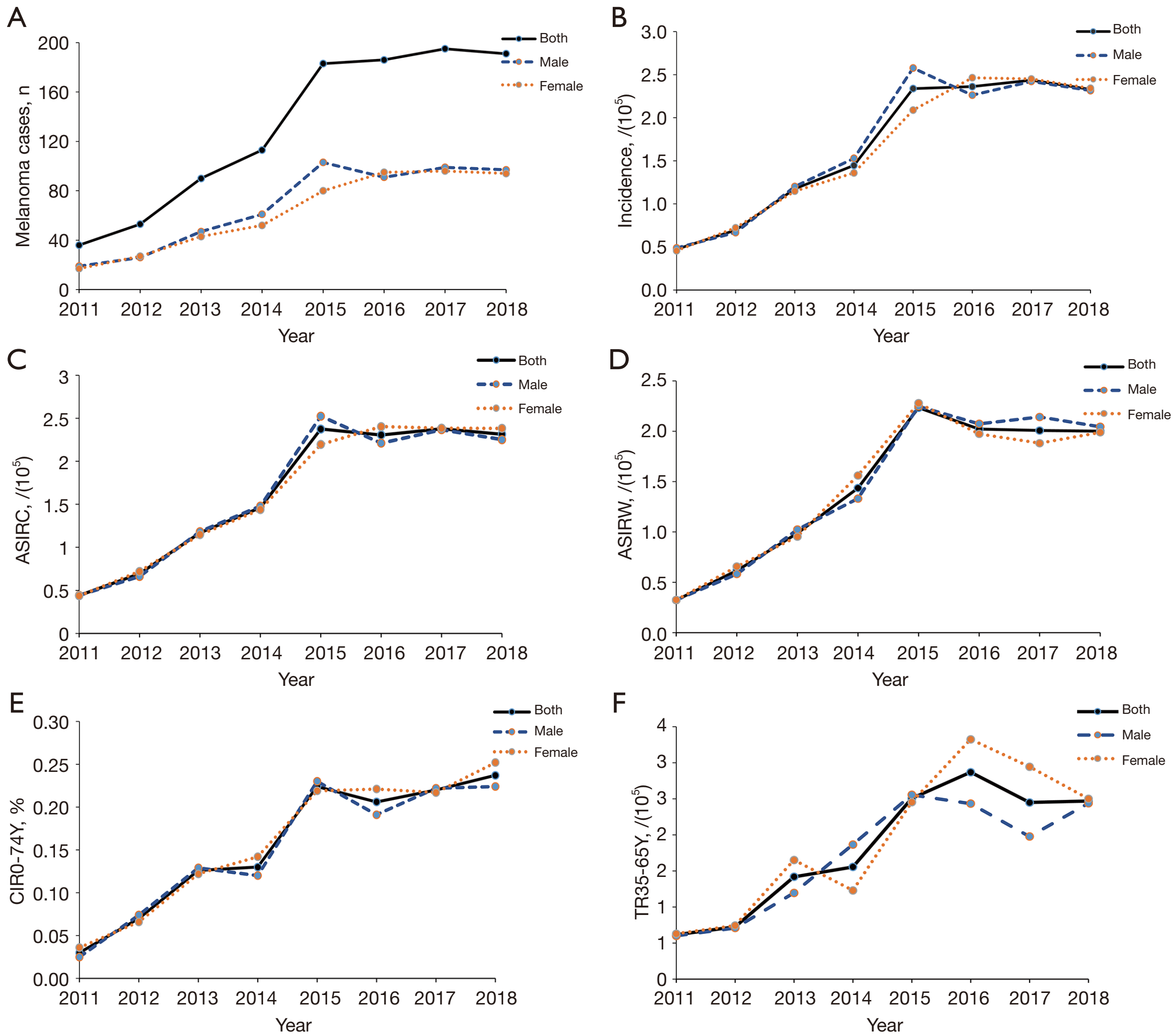

Figure 1 Melanoma incidence trends among different genders in Ningbo from 2011 to 2018. (A) The number of melanoma cases in Ningbo from 2011 to 2018. (B) The melanoma incidence rate from 2011 to 2018. (C) The coarse incidence rate of ASIRC. (D) The coarse incidence rate of ASIRW. (E) The coarse incidence rate of CIR0-74Y. (F) The coarse incidence rate of TR35-64Y. ASIRC, the age-standardized incidence rate by Chinese standard population; ASIRW, the age-standardized incidence rate by world standard population; CIR0-74Y, the cumulative morbidity of people aged 0–74; TR35-64Y, the truncation rate of people aged 35–64.

Ningbo. To investigate the reasons for this, we assessed various indicators of medical resources in different regions, including the number per 1,000 people of medical beds (MBPOTP), hospital beds (HBPOTP), health service workers (HSWPOTP), health workers (HWPOTP), practicing doctors (PDPOTP), and registered nurses (RNPOTP). As shown in *Table 6*, the results showed that the incidence of melanoma in districts with plentiful medical resources was higher than that in districts with poor medical resources. Pearson correlation analysis was used to study the correlation between melanoma incidence and medical resources using these 6 indicators. The results showed that melanoma incidence was strongly correlated with RNPOTP (correlation value: 0.609; $P<0.01$) and moderately correlated with MBPOTP (correlation value: 0.556; $P<0.01$), HBPOTP (correlation value: 0.563; $P<0.01$), HSWPOTP (correlation value: 0.559; $P<0.01$), HWPOTP (correlation value: 0.563; $P<0.01$), and PDPOTP (correlation value: 0.558; $P<0.01$). Therefore, melanoma incidence was significantly positively correlated with the above 6 indicators of medical resources. We then conducted a Ridge regression analysis, taking the above 6

Table 2 Progressive melanoma incidence in different gender populations in Ningbo from 2011 to 2018

Year	Gender	N	Population	Incidence (per 100,000)	ASIRC (per 100,000)	ASIRW (per 100,000)	CIR0-74Y (%)	TR35-64Y (per 100,000)
2011	Both	36	7,628,000	0.472	0.440	0.323	0.030	0.615
	Male	19	3,894,956	0.488	0.443	0.325	0.025	0.601
	Female	17	3,733,044	0.455	0.437	0.326	0.036	0.629
2012	Both	51	7,639,000	0.668	0.667	0.593	0.067	0.698
	Male	26	3,900,573	0.667	0.674	0.631	0.075	0.654
	Female	25	3,738,427	0.669	0.656	0.550	0.058	0.743
2013	Both	78	7,663,000	1.018	1.013	0.828	0.109	1.224
	Male	42	3,912,828	1.073	1.045	0.854	0.114	1.087
	Female	36	3,750,172	0.960	0.970	0.803	0.103	1.367
2014	Both	77	7,811,000	0.986	0.992	0.959	0.087	1.010
	Male	34	3,988,398	0.852	0.886	0.959	0.081	0.747
	Female	43	3,822,602	1.125	1.110	0.950	0.093	1.285
2015	Both	133	7,825,000	1.700	1.721	1.621	0.159	1.907
	Male	75	3,995,547	1.877	1.833	1.612	0.166	1.917
	Female	58	3,829,453	1.515	1.581	1.689	0.153	1.897
2016	Both	131	7,875,000	1.663	1.631	1.440	0.150	1.949
	Male	61	4,021,078	1.517	1.492	1.413	0.132	1.481
	Female	70	3,853,922	1.816	1.776	1.471	0.168	2.439
2017	Both	122	8,005,000	1.524	1.481	1.225	0.135	1.518
	Male	60	4,087,457	1.468	1.414	1.263	0.128	1.145
	Female	62	3,917,543	1.583	1.552	1.203	0.142	1.908
2018	Both	137	8,202,000	1.670	1.668	1.469	0.171	1.689
	Male	67	4,188,048	1.600	1.568	1.466	0.152	1.524
	Female	70	4,013,952	1.744	1.780	1.492	0.193	1.863
Total	Both	765	62,648,000	1.213±0.49	1.202±0.492	1.057±0.46	0.113±0.049	1.326±0.522
	Male	384	31,988,886	1.193±0.496	1.17±0.483	1.065±0.449	0.109±0.046	1.145±0.471
	Female	381	30,659,114	1.233±0.509	1.233±0.517	1.061±0.485	0.118±0.055	1.516±0.624

ASIRC, the age-standardized incidence rate by Chinese standard population; ASIRW, the age-standardized incidence rate by world standard population; CIR0-74Y, the cumulative morbidity of people aged 0–74; TR35-64Y, the truncation rate of people aged 35–64.

indicators as independent variables and melanoma incidence as the dependent variable. With a K value of 0.880 and an R squared value of 0.325, the results suggested that the 6 indicators of medical resources could explain the 32.54% of the variation in the data. The model passed the F test ($F=5.870$; $P<0.05$), and the formula was as follows: melanoma incidence = −0.752 + 0.029 × MBPOTP + 0.033 × HBPOTP + 0.019 × HSWPOTP + 0.022 × HWPOTP + 0.059 × PDPOTP + 0.092 × RNPOTP. This indicated that the 6 indicators of medical resources all had a significant positive influence on the incidence of melanoma ($P<0.01$).

Reasons for the difference in melanoma distribution

Table 3 Different types of melanoma in Ningbo from 2011 to 2018

Year	Gender	Melanoma types, n (%)						Two-factor ANOVA/ chi-squared test	
		Cutaneous	Mucosa	Eye	Central nervous system	Unspecified	Total	F/χ^2	P
2011	Both	15 (78.95)	2 (10.53)	2 (10.53)	0 (0.00)	0 (0.00)	19	2.729	0.099
	Male	13 (76.47)	3 (17.65)	0 (0.00)	0 (0.00)	1 (5.88)	17		
	Female	28 (77.78)	5 (13.89)	2 (5.56)	0 (0.00)	1 (2.78)	36		
2012	Both	17 (65.38)	4 (15.38)	1 (3.85)	2 (7.69)	2 (7.69)	26		
	Male	21 (77.78)	5 (18.52)	0 (0.00)	0 (0.00)	1 (3.70)	27		
	Female	38 (71.70)	9 (16.98)	1 (1.89)	2 (3.77)	3 (5.66)	53		
2013	Both	35 (74.47)	6 (12.77)	3 (6.38)	0 (0.00)	3 (6.38)	47		
	Male	29 (67.44)	10 (23.26)	1 (2.33)	0 (0.00)	3 (6.98)	43		
	Female	64 (71.11)	16 (17.78)	4 (4.44)	0 (0.00)	6 (6.67)	90		
2014	Both	29 (54.72)	6 (11.32)	3 (5.66)	0 (0.00)	15 (28.30)	53		
	Male	42 (70.00)	8 (13.33)	0 (0.00)	0 (0.00)	10 (16.67)	60		
	Female	71 (62.83)	14 (12.39)	3 (2.65)	0 (0.00)	25 (22.12)	113		
2015	Both	62 (60.19)	18 (17.48)	1 (0.97)	0 (0.00)	22 (21.36)	103		
	Male	55 (68.75)	12 (15.00)	3 (3.75)	0 (0.00)	10 (12.50)	80		
	Female	117 (63.93)	30 (16.39)	4 (2.19)	0 (0.00)	32 (17.49)	183		
2016	Both	56 (61.54)	16 (17.58)	4 (4.40)	2 (2.20)	13 (14.29)	91		
	Male	55 (57.89)	18 (18.95)	1 (1.05)	3 (3.16)	18 (18.95)	95		
	Female	111 (59.68)	34 (18.28)	5 (2.69)	5 (2.69)	31 (16.67)	186		
2017	Both	53 (53.54)	16 (16.16)	0 (0.00)	1 (1.01)	29 (29.29)	99		
	Male	52 (54.17)	17 (17.71)	4 (4.17)	1 (1.04)	22 (22.92)	96		
	Female	105 (53.85)	33 (16.92)	4 (2.05)	2 (1.03)	51 (26.15)	195		
2018	Both	61 (62.89)	17 (17.53)	2 (2.06)	0 (0.00)	17 (17.53)	97		
	Male	62 (65.96)	14 (14.89)	5 (5.32)	0 (0.00)	13 (13.83)	94		
	Female	123 (64.40)	31 (16.23)	7 (3.66)	0 (0.00)	30 (15.71)	191		
Total	Both	328 (61.31)	85 (15.89)	16 (2.99)	5 (0.93)	101 (18.88)	535	2.721	0.606
	Male	329 (64.26)	87 (16.99)	14 (2.73)	4 (0.78)	78 (15.23)	512		
	Female	657 (62.75)	172 (16.43)	30 (2.87)	9 (0.86)	179 (17.10)	1,047		

ANOVA, analysis of variance.

between urban and rural regions in Ningbo

The above results showed that there was significant difference in melanoma incidence between urban and rural districts of Ningbo, with high incidence in urban areas and low incidence in rural areas. To compare the data, we rearranged the districts into urban and rural areas. As shown in *Table 7*, melanoma incidence in urban areas was $2.925\pm1.065/(10^5)$, which was higher than that in rural areas [$1.012\pm0.632/(10^5)$], and the difference was statistically significant (t=4.369; P=0.001). From 2011 to 2018, the incidence rate in rural areas increased by 794.15%, which was 3 times higher than the incidence rate increase in

Table 4 Distribution of melanoma in Ningbo districts from 2011 to 2018

Districts	Year, n (%)									Chi-squared test	
	2011	2012	2013	2014	2015	2016	2017	2018	Total	χ^2	P
Haishu	4 (11.11)	10 (18.87)	8 (8.89)	15 (13.27)	10 (5.46)	11 (5.91)	12 (6.15)	21 (10.99)	91 (8.69)		
Yinzhou (including Jiangdong)	13 (36.11)	15 (28.30)	24 (26.67)	22 (19.47)	39 (21.31)	36 (19.35)	32 (16.41)	38 (19.90)	219 (20.92)		
Jiangbei	2 (5.56)	6 (11.32)	8 (8.89)	7 (6.19)	13 (7.10)	10 (5.38)	13 (6.67)	14 (7.33)	73 (6.97)		
Zhenhai	3 (8.33)	7 (13.21)	8 (8.89)	10 (8.85)	16 (8.74)	14 (7.53)	15 (7.69)	21 (10.99)	94 (8.98)		
Beilun	4 (11.11)	0 (0.00)	12 (13.33)	11 (9.73)	17 (9.29)	12 (6.45)	13 (6.67)	14 (7.33)	83 (7.93)		
Fenghua	0 (0.00)	2 (3.77)	6 (6.67)	6 (5.31)	5 (2.73)	18 (9.68)	16 (8.21)	10 (5.24)	63 (6.02)		
Cixi	3 (8.33)	2 (3.77)	1 (1.11)	6 (5.31)	6 (3.28)	4 (2.15)	8 (4.10)	7 (3.66)	37 (3.53)		
Ninghai	0 (0.00)	3 (5.66)	5 (5.56)	3 (2.65)	11 (6.01)	9 (4.84)	9 (4.62)	8 (4.19)	48 (4.58)	124.379	0.003**
Xiangshan	1 (2.78)	2 (3.77)	2 (2.22)	13 (11.50)	11 (6.01)	14 (7.53)	8 (4.10)	13 (6.81)	64 (6.11)		
Yuyao	2 (5.56)	2 (3.77)	2 (2.22)	4 (3.54)	26 (14.21)	15 (8.06)	17 (8.72)	19 (9.95)	87 (8.31)		
Other areas of Zhejiang Province	3 (8.33)	1 (1.89)	4 (4.44)	2 (1.77)	7 (3.83)	13 (6.99)	19 (9.74)	7 (3.66)	56 (5.35)		
Outside Zhejiang Province	1 (2.78)	3 (5.66)	6 (6.67)	7 (6.19)	12 (6.56)	23 (12.37)	26 (13.33)	11 (5.76)	89 (8.50)		
Unknown	0 (0.00)	0 (0.00)	4 (4.44)	7 (6.19)	10 (5.46)	7 (3.76)	7 (3.59)	8 (4.19)	43 (4.11)		
Total	36	53	90	113	183	186	195	191	1,047		

**, P<0.01.

Table 5 Distribution of melanoma in Ningbo districts from 2011 to 2018

Districts	Year, n (%)									Chi-squared test	
	2011	2012	2013	2014	2015	2016	2017	2018	Total	χ^2	P
Haishu	4 (11.11)	10 (18.87)	8 (8.89)	15 (13.27)	10 (5.46)	11 (5.91)	12 (6.15)	21 (10.99)	91 (8.69)		
Yinzhou (including Jiangdong)	13 (36.11)	15 (28.30)	24 (26.67)	22 (19.47)	39 (21.31)	36 (19.35)	32 (16.41)	38 (19.90)	219 (20.92)		
Jiangbei	2 (5.56)	6 (11.32)	8 (8.89)	7 (6.19)	13 (7.10)	10 (5.38)	13 (6.67)	14 (7.33)	73 (6.97)		
Zhenhai	3 (8.33)	7 (13.21)	8 (8.89)	10 (8.85)	16 (8.74)	14 (7.53)	15 (7.69)	21 (10.99)	94 (8.98)		
Beilun	4 (11.11)	0 (0.00)	12 (13.33)	11 (9.73)	17 (9.29)	12 (6.45)	13 (6.67)	14 (7.33)	83 (7.93)		
Fenghua	0 (0.00)	2 (3.77)	6 (6.67)	6 (5.31)	5 (2.73)	18 (9.68)	16 (8.21)	10 (5.24)	63 (6.02)		
Cixi	3 (8.33)	2 (3.77)	1 (1.11)	6 (5.31)	6 (3.28)	4 (2.15)	8 (4.10)	7 (3.66)	37 (3.53)		
Ninghai	0 (0.00)	3 (5.66)	5 (5.56)	3 (2.65)	11 (6.01)	9 (4.84)	9 (4.62)	8 (4.19)	48 (4.58)	124.379	0.003**
Xiangshan	1 (2.78)	2 (3.77)	2 (2.22)	13 (11.50)	11 (6.01)	14 (7.53)	8 (4.10)	13 (6.81)	64 (6.11)		
Yuyao	2 (5.56)	2 (3.77)	2 (2.22)	4 (3.54)	26 (14.21)	15 (8.06)	17 (8.72)	19 (9.95)	87 (8.31)		
Other areas of Zhejiang Province	3 (8.33)	1 (1.89)	4 (4.44)	2 (1.77)	7 (3.83)	13 (6.99)	19 (9.74)	7 (3.66)	56 (5.35)		
Outside Zhejiang Province	1 (2.78)	3 (5.66)	6 (6.67)	7 (6.19)	12 (6.56)	23 (12.37)	26 (13.33)	11 (5.76)	89 (8.50)		
Unknown	0 (0.00)	0 (0.00)	4 (4.44)	7 (6.19)	10 (5.46)	7 (3.76)	7 (3.59)	8 (4.19)	43 (4.11)		
Total	36	53	90	113	183	186	195	191	1,047		

**, P<0.01.

Table 6 Correlation analysis of melanoma incidence and indicators of medical resources among the registered population of Ningbo from 2011 to 2018

Districts	Medical resource index, $\bar{x}$ ± s						Incidence (per 100,000)
	MBPOTP	HBPOTP	HSWPOTP	HWPOTP	PDPOTP	RNPOTP	
Haishu	16.677±3.743	16.581±3.678	29.136±5.758	24.95±5.023	9.201±1.656	9.704±2.259	3.087±1.131
Yinzhou (including Jiangdong)	6.457±2.055	6.404±2.057	13.8±3.765	11.42±2.961	4.376±1.033	4.48±1.565	2.672±1.056
Jiangbei	8.578±1.206	8.522±1.179	17.444±2.576	14.193±1.902	5.189±0.665	6.058±0.968	3.686±1.622
Zhenhai	8.676±1.228	8.722±1.139	15.695±2.326	13.125±1.964	4.93±0.752	5.268±0.771	4.561±2.188
Beilun	5.823±1.842	5.644±1.703	12.675±3.419	10.788±2.821	4.324±1.102	4.172±1.137	2.845±1.661
Fenghua	4.746±0.472	4.647±0.48	8.651±1.095	6.531±0.799	2.707±0.227	2.424±0.425	1.63±1.32
Cixi	3.743±0.393	3.468±0.418	9.572±1.336	7.584±0.641	3.103±0.332	2.82±0.385	0.441±0.237
Ninghai	3.327±0.622	2.822±0.378	7.723±1.062	6.043±0.439	2.365±0.176	2.204±0.347	0.955±0.604
Xiangshan	3.37±0.531	3.532±0.815	6.997±1.044	5.702±0.69	2.267±0.235	2.18±0.296	1.458±1.009
Yuyao	3.458±0.431	3.418±0.402	8.683±1.196	6.838±0.868	2.629±0.324	2.741±0.432	1.3±1.136
Pearson analysis							
Correlation index	0.556	0.563	0.559	0.563	0.558	0.609	–
P	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	–
Ridge regression analysis							
t	3.831	4.071	3.99	4.898	4.167	6.83	F(6,73)=5.870, P=0.000**
P	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	

**, P<0.01. MBPOTP, the number per 1,000 people of medical beds; HBPOTP, the number per 1,000 people of hospital beds; HSWPOTP, the number per 1,000 people of health service workers; HWPOTP, the number per 1,000 people of health workers; PDPOTP, the number per 1,000 people of practicing doctors; RNPOTP, the number per 1,000 people of registered nurses.

Table 7 Melanoma incidence among registered residents in urban and rural areas of Ningbo from 2011 to 2018

Year	Urban areas of Ningbo			Rural areas of Ningbo			*T*-test	
	Cases, n (%)	Registered population	Incidence (per 100,000)	Cases, n (%)	Registered population	Incidence (per 100,000)	*t*	P
2011	26 (81.25)	2,247,378	1.157	6 (18.75)	3,516,664	0.171	4.369	0.001**
2012	38 (77.55)	2,262,116	1.68	11 (22.45)	3,516,009	0.313		
2013	60 (78.95)	2,275,941	2.636	16 (21.05)	3,525,523	0.454		
2014	65 (67.01)	2,296,382	2.831	32 (32.99)	3,541,385	0.904		
2015	95 (61.69)	2,321,297	4.093	59 (38.31)	3,544,434	1.665		
2016	83 (53.9)	2,842,155	3.554	60 (38.96)	3,067,473	1.369		
2017	101 (70.63)	2,896,290	3.487	42 (29.37)	3,073,017	1.367		
2018	118 (71.52)	2,955,704	3.992	47 (28.48)	3,073,864	1.529		

**, P<0.01.

Table 8 Correlation analysis of melanoma incidence and indicators of medical resources among the registered population in urban and rural areas of Ningbo from 2011 to 2018

Medical related indexes	Districts, $\bar{x}$ ± s		Pearson analysis		Ridge regression analysis	
	Urban areas of Ningbo	Rural areas of Ningbo	Correlation index	P	*t*	P
MBPOTP	8.114±0.614	3.642±0.395	0.87	0.000**	3.831	0.000**
HBPOTP	7.644±1.522	3.405±0.476	0.888	0.000**	4.071	0.000**
HSWPOTP	15.989±1.399	8.073±0.793	0.89	0.000**	3.99	0.000**
HWPOTP	12.878±2.082	6.701±0.681	0.9	0.000**	4.898	0.000**
PDPOTP	4.918±0.747	2.678±0.271	0.905	0.000**	4.167	0.000**
RNPOTP	5.059±1.047	2.542±0.382	0.925	0.000**	6.83	0.000**
Incidence	2.925±1.065	1.135±1.631	–	–	F(6,73)=5.870, P=0.000	

**, P<0.01. MBPOTP, the number per 1,000 people of medical beds; HBPOTP, the number per 1,000 people of hospital beds; HSWPOTP, the number per 1,000 people of health service workers; HWPOTP, the number per 1,000 people of health workers; PDPOTP, the number per 1,000 people of practicing doctors; RNPOTP, the number per 1,000 people of registered nurses.

urban areas (245.03%). Next, we analyzed the relationship between incidence rate and the 6 indicators of medical resources (*Table 8*). The results showed that all 6 indicators of medical resources were strongly correlated with melanoma incidence in urban and rural areas. Correlation values for MBPOTP, HBPOTP, HSWPOTP, PDPOTP, and RNPOTP were 0.870, 0.888, 0.890, 0.900, 0.905, and 0.925, respectively, with P<0.01. We then conducted a Ridge regression analysis, taking the 6 indicators of medical resources as independent variables and the melanoma incidence as the dependent variable. With a K value of 0.990 and an R squared value of 0.807, the results indicated that the 6 indicators of medical resources could explain 80.72% of the variation in the data. The model passed the F test (F=6.282; P<0.05), and the formula was as follows: melanoma incidence = −0.734 + 0.063 × MBPOTP + 0.064 × HBPOTP + 0.040 × HSWPOTP + 0.047 × HWPOTP + 0.134 × PDPOTP + 0.138 × RNPOTP. This indicated that the above 6 indicators of medical resources all had a significant positive influence on the incidence of melanoma (P<0.01).

Distribution of melanoma treatment in different types of hospitals in Ningbo from 2011 to 2018

As shown in *Table 9*, we compared the different types of hospitals in which patients with melanoma in Ningbo received treatment from 2011 to 2018. The results showed that 659 patients (62.94%) were treated in municipal hospitals, 290 patients (27.7%) were treated in county and district hospitals, and only 98 patients (9.36%) were treated in community health hospitals. The difference was statistically significant (χ^2=96.011; P=0.000). Although the number of cases of melanoma diagnosis and treatment across all types of hospitals increased from 2011 to 2018, the proportion of patients treated in municipal hospitals decreased (*Figure 2*). Cases in county and district hospitals rose from 13.89% in 2011 to a high of 40.32% in 2016, while cases in community hospitals also rose from 0% in 2011 to 15.18% in 2018, which reflects improvements in medical resources and melanoma diagnosis.

Discussion

At present, there are few studies on the epidemiology of melanoma in China, and exiting studies have problems such as small sample sizes (4,5), or data from the National Cancer Registry, which may be underreported (3,6). Registration of tumors in China began in 1950, and in 2002 the government set up a national cancer registry. After 60 years of development, there are now 574 cancer registries in China covering a population of 438 million, which was 31.51% of the total population at the end of 2017. These registries include tumor registration and a follow-up monitoring network (14). Although incidence information from 36 Chinese cancer registries was included in the Cancer Incidence in Five Continents Volume XI for the first time in 2017 (15), the percentage of Chinese databases included is only 6.27% (36/574), and the quality of the registration data is not high. In addition, current

Table 9 Distribution of melanoma in different types of hospitals in Ningbo from 2011 to 2018

Year	Hospital type, n (%)				Chi-squared test	
	Municipal hospital	County and district hospitals	Community health hospitals	Total	χ^2	P
2011	31 (86.11)	5 (13.89)	0 (0.00)	36 (3.44)	96.011	0.000**
2012	46 (86.79)	7 (13.21)	0 (0.00)	53 (5.06)		
2013	75 (83.33)	14 (15.56)	1 (1.11)	90 (8.60)		
2014	92 (81.42)	15 (13.27)	6 (5.31)	113 (10.79)		
2015	105 (57.38)	56 (30.60)	22 (12.02)	183 (17.48)		
2016	97 (52.15)	75 (40.32)	14 (7.53)	186 (17.77)		
2017	120 (61.54)	49 (25.13)	26 (13.33)	195 (18.62)		
2018	93 (48.69)	69 (36.13)	29 (15.18)	191 (18.24)		
Total	659 (62.94)	290 (27.70)	98 (9.36)	1,047	–	–

**, P<0.01.

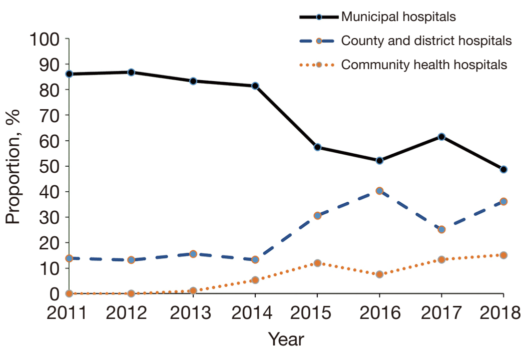

Figure 2 Distribution trend of melanoma cases in different types of hospitals in Ningbo from 2011 to 2018 (municipal hospitals, county and district hospitals, community health hospitals).

tumor registration centers still encounter shortcomings such as an insufficient number and uneven distribution of tumor registration centers; a high percentage of manual collection; difficulties ensuring the quality and reliability of basic data; time-consuming data cleaning, processing, and analysis; and insufficient depth and breadth of tumor registration data (14). An epidemiological study in Europe showed that the incidence of melanoma varies greatly among European countries due to delayed diagnosis and differences in reporting or registration. For example, the incidence of melanoma in Switzerland and Greece is 19.2 per 100,000 and 2.2 per 100,000, respectively (16). A 2018 report showed that melanoma was particularly vulnerable to underreporting, even in the United States where there is an effective tumor registration and monitoring system. Half of the doctors surveyed were not aware of the requirement to report melanoma, and 56% did not actively report the melanoma diagnosis (17). Similarly, previous epidemiological studies of melanoma in China may not reflect the actual incidence of melanoma. Previous studies have shown a high incidence of melanoma in eastern China (3,6), but there is a lack of epidemiological research on melanoma in these high-incidence cities. The current unified national health information collection and exchange platform can facilitate the automatic capture of tumor registration monitoring data, improving the quality, credibility, data continuity, and timeliness of registration data, and can increase the practical value of registration by providing real-time sharing and timely services for evidence-based decisions (18). Therefore, we used the National Health Information Platform of Ningbo City combined with the diagnostic data of the Ningbo clinicopathological diagnosis center to more accurately reflect the incidence of melanoma in Ningbo.

Our research showed that the total incidence of melanoma in Ningbo from 2011 to 2018 was roughly 1.657 per 100,000. Crude incidence in 2017 was 2.436 per 100,000, which was far higher than the incidence rate of 1.5 per 100,000 reported by the cancer registry for eastern China (3). However, once melanoma *in situ* was removed from the data, the crude incidence rate became 1.524 per 100,000, which conformed to the previously reported data. A study of pathological examinations in Waikato, New Zealand, showed that the incidence of melanoma in this region was 55.2 per 100,000, while the incidence of invasive melanoma in males and females was 34.3 per 100,000 and 41.4 per 100,000, respectively, which was very similar to the incidence rate in the New Zealand National Cancer Registry at the same time (19). This suggested that these cancer registries omitted early-stage melanomas from the data, thereby underestimating the incidence and disease burden of melanoma. This may be due to the fact that melanoma has many different source sites, categories, types, and stages (9), which all lead to significant differences in clinical manifestations, treatment, and prognosis, while melanoma *in situ* can often be cured by outpatient surgical resection (19,20).

Our data showed that the age-standardized incidence of melanoma in Ningbo City had increased by 521.67% in 2018 compared with that in 2011, which was higher than the increase in the national incidence rate from 1990 to 2017 (110.3%) and much higher than the increase in the global incidence rate from 1990 to 2017 (41.2%) (3). This may be a result of including early melanoma in our study. From 2011 to 2018, the incidence of melanoma *in situ* in Ningbo City was about 26.93%, and the proportion increased year by year. A number of international studies have shown that in recent years, melanoma *in situ* rates have increased more than those of invasive melanoma (19,21-23), with melanoma *in situ* accounting for nearly 40% of melanoma cases (19). This may be the reason why the incidence of melanoma has continued to rise in the world, but the mortality rate of melanoma has not risen to match it. Although the relationship between melanoma *in situ* and invasive melanoma is still controversial (20,24,25), it is generally believed that invasive melanomas originate from melanomas *in situ* (26), and that removal of a melanoma *in situ* can effectively prevent the occurrence of invasive melanoma, thus improving prognosis.

According to a World Health Organization (WHO) report, the incidence of skin melanoma in developed countries is significantly higher than that of developing countries (27-30). In China, the east and northeast provinces (3) have higher melanoma incidence rates than those of the western provinces, while urban areas have higher rates than those of rural areas (31). These trends cannot be fully explained by race, healthy living habits, or UV irradiation, as there are many contradictions in the data. The population in western China may suffer more UV irradiation, which may explain melanoma DALYs diminishing from the western provinces to the eastern province (3), but this is not consistent with the incidence rate difference between eastern and western regions. This suggests that diagnosis, misdiagnosis, and treatment delay or omission may be possible reasons for the lower incidence in western regions. In rural areas of China, the most common types of melanoma are acral melanoma, accounting for 50% of cases, followed by mucous membrane, accounting for 20–30% of cases (7,10,11). The most common type of melanoma among farmers, acral melanoma (66%) (12), may be associated with trauma caused by repeated infection, especially in the lower limbs (13). According to the above factors, the incidence of melanoma in rural areas should be higher than that in the city. This discrepancy may be caused by underreporting in rural areas, as the tumor registries included in previous studies (6) account for only about 4% of the total population in China, with much higher coverage in urban areas.

In this paper, we hypothesized that the uneven distribution of medical resources may be the cause of differences in incidence rates (32-34) between developed and developing countries, the eastern and western regions of China, and rural and urban areas in China. Therefore, we analyzed the incidence of melanoma in the registered population of each county and urban area in Ningbo City from 2011 to 2018. The results showed that in Yinzhou District, the average yearly number of melanoma cases was 27.38±10.31, and the occupancy was 27.68%±6.3%, which was much higher than the average number of cases (10.74±8.44) and occupancy (10%±7.35%) in the city as a whole. The lowest rate was in Cixi City (4.63±2.5 and 4.69%±2.43%). Using the Ningbo census register, we calculated that the melanoma incidence in Ningbo by population was 2.26±1.75/(10^5). The highest incidence was in Zhenhai with a rate of 4.56±2.19/(10^5), and the lowest incidence was in Cixi City with a rate of 0.44±0.24/(10^5), a difference of nearly 10 times. Regardless of the number and proportion, each interval incidence rate showed an obvious statistical difference ($P<0.003$). Pearson correlation analysis was used to assess incidence rate differences combined with indicators of medical resources among regions. The results showed that melanoma incidence was strongly correlated with the RNPOTP (correlation value: 0.609; $P<0.01$), and moderately correlated with the other 5 indexes (correlation value: 0.5–0.6; $P<0.01$). Ridge regression analysis was conducted using the incidence as the dependent variable. The K value was 0.880, suggesting that all the indicators of medical resources had a significant positive impact on the incidence of melanoma in each county (F=5.870; P=0.000; regression coefficient value: 0.019–0.092; P<0.01). Therefore, these indicators can account for the 32.54% of the variation. As farmers make up a majority of the population in rural counties under the jurisdiction of Ningbo, we categorized the districts into rural and urban areas. The rural-urban statistical results showed that the melanoma incidence in Ningbo urban areas was $2.925\pm1.065/(10^5)$, which was significantly higher than the rate of $1.012\pm0.632/(10^5)$ in urban areas, with a statistically significant difference (t=4.369; P=0.001). The melanoma incidence rate in rural regions of Ningbo grew by 794.15% from 2011 to 2018, which was 3 times higher than the corresponding growth rate in urban areas (245.03%). According to the Pearson correlation analysis, the indicators of medical resources were strongly positively correlated with melanoma incidence (correlation values were all greater than 0.8; P<0.01). According to the Ridge regression analysis, all 6 indicators of medical resources had a significant positive impact on the incidence of melanoma in the urban areas of Ningbo and the counties and cities under the jurisdiction of Ningbo (K=0.990; F=6.282; P=0.008). Therefore, these indicators could account for the 80.72% of the variation.

The above results suggested that differences in the distribution of medical resources may be a reason for the differences in melanoma incidence between developed countries and developing countries, the eastern and western regions of China, and rural and urban areas in China. In addition, these results may shed light on discrepancies between the previously reported melanoma incidence and DALYs of eastern and western China, the higher morbidity in urban areas than in rural areas, and the incidence of acral lentiginous melanoma tumor types. These discrepancies may be attributed to a lack of medical resources, diagnosis and misdiagnosis, and treatment delay or omission. Interestingly, our study found that 62.94% of melanoma patients were treated in municipal hospitals from 2011 to 2018, but the proportion had dropped to 48.69% in 2018 and to 86.79% in 2012. Meanwhile, treatment rates in district and county hospitals and community hospitals have increased every year, particularly in county and district hospitals, which have seen a clear increase of 23% from 2011 to 2018. With increasing medical investment, the diagnosis and treatment of melanoma in county and district hospitals and community hospitals has improved.

Despite the unequal distribution of medical resources and other problems still outstanding, health data from 2010 to 2015 has increased year by year with increasing input to Chinese medical and health systems, and the output of overall productivity growth appeared a downward trend, decreased productivity growth and urban areas than in rural areas (32). The average health technology progress index in eastern rural areas is higher than that in urban areas (32). This is also consistent with our data. Although the increase of rural medical resources in Ningbo did not differ from that in cities, the increase of melanoma incidence was 3 times that in cities. Therefore, we should pay more attention to investment in China's rural areas and western regions where medical resources are less available.

Acknowledgments

Funding: This work was supported by the Natural Science Foundation of Ningbo (No. 2019A610322).

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://apm.amegroups.com/article/view/10.21037/apm-21-3942/rc

Data Sharing Statement: Available at https://apm.amegroups.com/article/view/10.21037/apm-21-3942/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://apm.amegroups.com/article/view/10.21037/apm-21-3942/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and informed consent was waived due to the retrospective nature of this study. The study was approved by the Ethics Committee of Ningbo First Hospital (No. 2020-R187), and other hospitals were informed and agreed with the study.

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(English Language Editor: C. Gourlay)

Cite this article as: Zhang M, Zhu J, Guo L, Gao K, Ding H, Tang L, Yan Z. An analysis of melanoma epidemic characteristics and distribution in the eastern Chinese city Ningbo from 2011 to 2018. Ann Palliat Med 2022;11(5):1736-1751. doi: 10.21037/apm-21-3942

