SCIENCE CHINA
Life Sciences

•REVIEW•

https://doi.org/10.1007/s11427-022-2240-6

Overview and countermeasures of cancer burden in China

Yian Wang[1,2,3], Qijia Yan[4], Chunmei Fan[2], Yongzhen Mo[2], Yumin Wang[4], Xiayu Li[3], Qianjin Liao[1], Can Guo[2], Guiyuan Li[1,2,3], Zhaoyang Zeng[1,2], Wei Xiong[1,2,3*] & He Huang[1,2,3*]

[1]*NHC Key Laboratory of Carcinogenesis and Hunan Key Laboratory of Cancer Metabolism, Hunan Cancer Hospital and the Affiliated Cancer Hospital of Xiangya School of Medicine, Central South University, Changsha 410078, China;*
[2]*Key Laboratory of Carcinogenesis and Cancer Invasion of the Chinese Ministry of Education, Cancer Research Institute, Central South University, Changsha 410078, China;*
[3]*Hunan Key Laboratory of Nonresolving Inflammation and Cancer, Disease Genome Research Center, The Third Xiangya Hospital, Central South University, Changsha 410078, China;*
[4]*Department of Otolaryngology Head and Neck Surgery, Xiangya Hospital, Central South University, Changsha 410078, China*

Received September 12, 2022; accepted November 3, 2022; published online April 13, 2023

Cancer is one of the leading causes of human death worldwide. Treatment of cancer exhausts significant medical resources, and the morbidity and mortality caused by cancer is a huge social burden. Cancer has therefore become a serious economic and social problem shared globally. As an increasingly prevalent disease in China, cancer is a huge challenge for the country's healthcare system. Based on recent data published in the *Journal of the National Cancer Center* on cancer incidence and mortality in China in 2016, we analyzed the current trends in cancer incidence and changes in cancer mortality and survival rate in China. And also, we examined several key risk factors for cancer pathogenesis and discussed potential countermeasures for cancer prevention and treatment in China.

cancer, incidence, mortality, survival, statistics, countermeasures, China

Citation: Wang, Y., Yan, Q., Fan, C., Mo, Y., Wang, Y., Li, X., Liao, Q., Guo, C., Li, G., Zeng, Z., et al. (2023). Overview and countermeasures of cancer burden in China. Sci China Life Sci 66, https://doi.org/10.1007/s11427-022-2240-6

Introduction

The *Journal of the National Cancer Center* recently published the latest issue of cancer statistics in China (Zheng et al., 2022). Due to the lag in information collection, this report summarizes the most current status of cancer incidence and mortality in China up to 2016. Data from 487 high-quality surveillance sites selected by the National Cancer Center of China (NCC) from 682 cancer surveillance sites nationwide are aggregated. The statistics covers about 381,565,422 people, accounting for 27.60% of the total national population at the end of 2016. The report provides a comprehensive picture of the current characteristics of cancer incidence and mortality in China from the perspectives of gender, age of incidence, and region of incidence (Zheng et al., 2022). Although the overall incidence and mortality rates of cancer in China continue to rise, the rates for some traditional high incidence cancers display a steady decreasing trend, and the survival rate of some cancers is gradually increasing (Zeng et al., 2018). The presence of an aging population makes the cancer control still a great challenge for our healthcare system (Chen et al., 2022). However, the gradually decreasing cancer incidence and mortality rates in developed countries under the same circumstance suggest that China can refer to the countermeasures of developed countries for cancer prevention and treatment (Xia et al., 2022).

*Corresponding authors (Wei Xiong, email: xiongwei@csu.edu.cn; He Huang, email: huanghe@csu.edu.cn)

Characteristics of cancer incidence, mortality and survival in china

Overall increase in cancer incidence and mortality in China

With the socio-economic development, the average life expectancy of humans has increased dramatically (Chen et al., 2021). However, with the advent of an aging population, a number of public health problems have also arisen (Tchkonia et al., 2021). Among them, a significant if not the most important one is the persistent increase in cancer incidence and mortality (Sun et al., 2020). In 2016, new cases of cancer in China arose to 4,064,000, with a crude incidence rate of 293.91/100,000. In the meantime, the age-standardized incidence rate for the world standard population (ASIRW) was 186.46/100,000. And there were 2,413,500 deaths from cancer in China in 2016, with a crude mortality rate of 174.55/100,000, while the age-standardized mortality rate for the world standard population (ASMRW) in that year was 105.19/100,000 (Zheng et al., 2022).

The latest data obtained from the National Cancer Surveillance Sites shows that the highest ASIRW for cancer among men in China is still lung cancer (49.78/100,000), followed by liver cancer (26.65/100,000), stomach cancer (25.14/100,000), colorectal cancer (21.65/100,000), and esophagus cancer (16.81/100,000). These five leading cancers account for approximately 68.83% of the annual new cancer diagnoses in men **(**Figure 1A**)**. Notably, the ASIRW for prostate cancer, colorectal cancer, leukemias, brain/central nervous system (CNS) cancer, pancreatic cancer, and bladder cancer in men are on the rise (Chen et al., 2018; Zheng et al., 2022). The highest ASIRW for cancer in women is breast cancer (29.05/100,000), followed by lung cancer (23.70/100,000), thyroid cancer (15.81/100,000), colorectal cancer (14.58/100,000), and cervical cancer (11.34/100,000). These five cancers account for approximately 56.11% of annual new cancer cases in women **(**Figure 1B**)**. Of note, the ASIRW for thyroid cancer, cervical cancer, uterine cancer, breast cancer, brain/CNS cancer, lung cancer, and colorectal cancer among women shows an upward trend (Chen et al., 2018; Zheng et al., 2022).

In terms of mortality, the highest rate in both males and females are lung cancer with a ASMRW of 40.58/100,000 for men and 16.24/100,000 for women. In men, the next most lethal cancer is liver cancer (22.90/100,000), followed by stomach cancer (17.77/100,000), esophagus cancer (12.73/100,000), and colorectal cancer (10.04/100,000). These five leading cancers account for approximately 75.87% of annual cancer deaths in men (Figure 2A**)**. Notably, the ASMRW for prostate cancer, colorectal cancer, pancreatic cancer, and leukemia in men are on the rise (Chen et al., 2018; Zheng et al., 2022). In women, the second deadly cancer is also liver cancer (7.27/100,000), followed by stomach cancer (7.13/100,000), female breast cancer (6.39/100,000), and colorectal cancer (6.36/100,000). These top five cancers account for approximately 60.06% of all cancer deaths in women (Figure 2B**)**. Of note, upticks are being seen in terms of death caused by cervical, thyroid, and breast cancer in women (Chen et al., 2018; Zheng et al., 2022). All over, with the exception of cancers of gallbladder and thyroid, mortality rates of all other cancers in men were higher than that in women.

Better prognosis and improved survival rates for some cancers

Although the incidence and mortality rates of cancer in China increase gradually in the last decade, the survival rate for cancer patients in China shows a steady upward trend. Currently, the age-standardized 5-year relative survival is about 40.5%, a 10% increase when compared with the overall survival rate of malignant tumors in China 10 years ago. Specifically, the age-standardized 5-year relative survival for uterine cancer (average change per calendar period: 5.5%), thyroid cancer (5.4%), cervical cancer (4.5%), and bone cancer (3.2%) were significantly improved (Zeng et al., 2018). Although the above data are survival statistics in China from 2003 to 2015. But it indicates that the efforts for cancer prevention and treatment in China has led to initial success in recent years, mush of which is owed to the following seven systems established by the National Cancer Center: the cancer diagnosis and treatment system, the quality control system, the anti-tumor drug detection system, the cancer science and technology research system, the tumor registration system, the early diagnosis and treatment system, and the comprehensive cancer prevention and control system. Currently, there are abundant treatment options for cancer patients in China, including surgical resection (Zhou and Song, 2021), chemotherapy (Yang et al., 2021), radiotherapy (Chen, 2020), immunotherapy (Zhang and Zhang, 2020), and endocrine therapy (Harbeck et al., 2021). The clinical treatment process is starting to be standardized and to be precisely targeted in accordance with the patient's personal condition, and appropriate treatment modality is selected by the stage of the cancer. In addition, basic biomedical research on tumor pathogenesis has been strongly supported in China, and the development of new drugs for cancer treatment is also encouraged by the government. Researchers in China are focusing on understanding the fundamental mechanisms of malignant tumor pathogenesis, drug resistance, and immune escape (Xu et al., 2022). Researchers also try hard to find new molecular targets for early cancer diagnosis (Wang et al., 2022) as well as to develop new drugs for precision cancer treatment (Syed, 2020). Furthermore, China has increased the reimbursement rate for medical insurance and included more expensive drugs into the medical insurance. The government

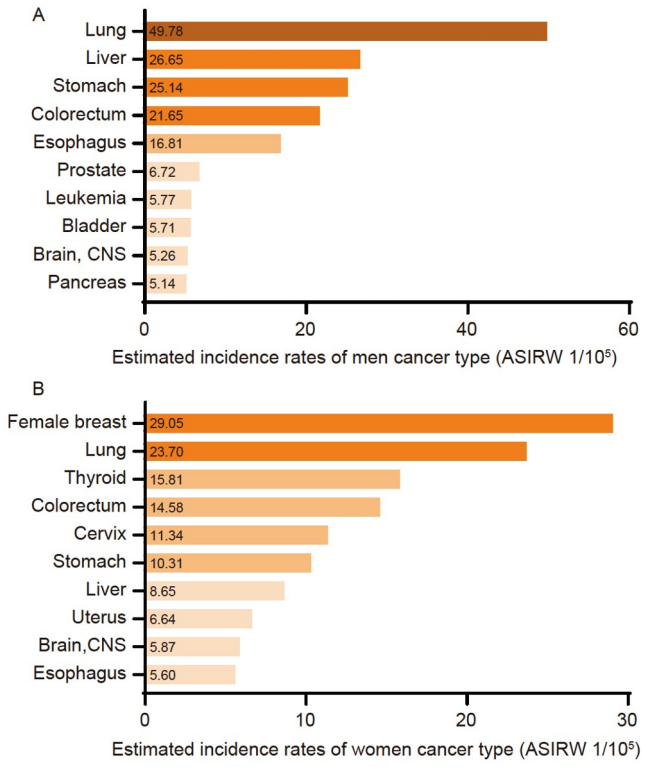

Figure 1 Ten leading cancer types by incidence in China (2016). A, Ten leading cancer types by incidence in men. B, Ten leading cancer types by incidence in women.

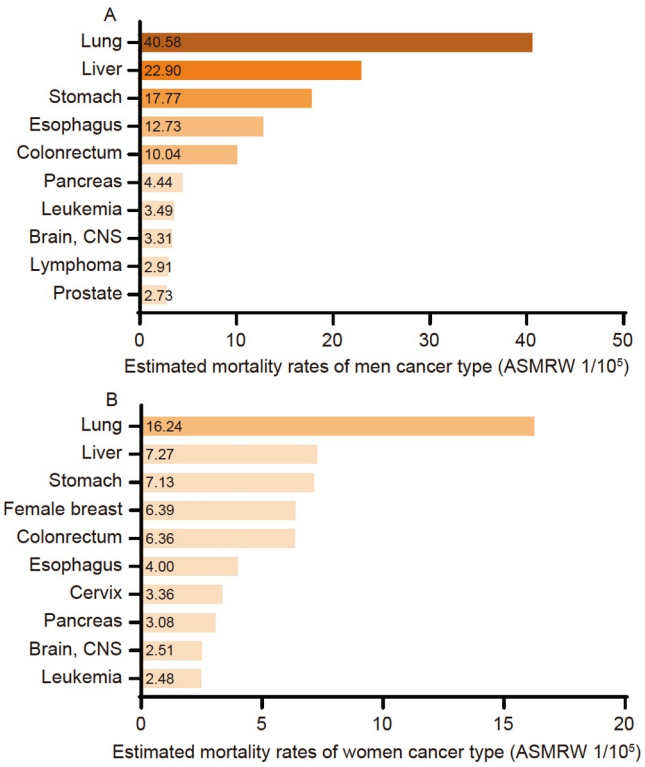

Figure 2 Ten leading cancer types by mortality in China (2016). A, Ten leading cancer types by mortality in men. B, Ten leading cancer types by mortality in women.

will continue to focus on procurement of generic and targeted antitumor drugs, greatly reducing the economic burden of cancer patients with substantial financial aids. Currently, China's urban early cancer diagnosis and treatment services have covered 75 cities in 29 provinces. The government also provides medical assistance to remote areas, and implements cancer screening and early detection programs in specific rural areas with high cancer incidence. The survival rate of cancer patients has been substantially improved by the above-mentioned approaches. In addition, the promotion of vaccination for cancers caused by viral infections has also contributed to the much better improved cancer survival rates (Wang et al., 2020).

Cancer spectrum in China is shifting towards that in developed countries

The main risk factors for cancer are genetic factors (Machlowska et al., 2020), environmental factors (Miranda-Galvis et al., 2021), and viral infections (Schiller and Lowy, 2021). With the socio-economic development, the changes of people's lifestyle, and the advent of an aging population, there are some shifts in the incidence of different types of cancers in China. The spectrum of cancer incidence in China is gradually converging to that of developed countries such as the United States (Xia et al., 2022). Cancers with the highest incidence and mortality rates in China in the last century are esophageal, gastric, and liver cancer (Yang et al., 2003). This is mainly related to the underdeveloped economy and poor dietary habits. Smoking, alcohol drinking, and consuming foods with excessive nitrosamines lead to higher incidence of esophageal (Uhlenhopp et al., 2020) and gastric cancer (Poorolajal et al., 2020). The communal meal system of the Chinese diet facilitates the transmission of *H. pylori*, which leads increased incidence of gastric cancer (Alipour, 2021). And in the past, widespread hepatitis B virus (HBV) infection in China is the major cause for high incidence of liver cancer (Chang, 2021). However, with the improvement of living standards, changes of lifestyle, and introduction of preventive measures such as vaccination, the incidence and mortality rates of stomach, liver, and esophageal cancer in China have gradually decreased (Feng et al., 2019). According to the data published so far, the incidence of colorectal cancer, breast cancer, thyroid cancer, and prostate cancer, which are highly prevalent in the United States starts to show an increasing trend in China. This is partly due to the changes of dietary habits. A high-fat, low-fiber diet similar to that in the developed countries led to increase of colorectal cancer (Yang et al., 2020). The high incidence of breast, thyroid, and prostate cancer, which are linked to the dyshomeostasis of hormones, may also reflect the current change into fast-paced lifestyle in China (Key, 1995). In addition,

obesity is an important contributing factor of the high incidence of the above cancers (Avgerinos et al., 2019). Despite the dramatic increase in the incidence of thyroid cancer, the mortality rate remains low and stable. It mainly owes to the improvement in current screening techniques, which enables early detection and treatment of many thyroid cancer patients (Krajewska et al., 2020; Xu and Han, 2021). The high incidence and mortality of lung cancer can be explained by heavy air pollution and large smoking population in China (Yang et al., 2020). In general, cancers with high incidence rates in China currently are lung, colorectal, stomach, liver, and breast cancer, and cancers with high mortality rates are lung, liver, stomach, esophageal, and colorectal cancer (Xia et al., 2022).

Cancers with high incidence rates in the developed countries such as the United States are breast cancer, lung cancer, prostate cancer, colorectal cancer, and skin melanoma. And cancers with high mortality rates are lung, colorectal, pancreatic, breast, and prostate cancers (Xia et al., 2022). The significant decline of lung and colorectal cancer incidence and mortality from historical high is due in large part to the decline in smoking rate in the United States (Jeon et al., 2018; Pacek and McClernon, 2018; Phillips et al., 2017). Lifestyle changes as well as new means of early screening, standardized treatment, and continued innovation in treatment modalities have led to a decline in the incidence and mortality of some cancers (Siegel et al., 2022). Interestingly, early screening with prostate cancer-specific antigens once led to a brief surge in prostate cancer incidence, but prostate cancer mortality rate continues to decline over time (Legler et al., 1998; Welch and Albertsen, 2009). This suggests that early screening indeed plays an important role in the reduction of cancer morbidity and mortality.

The current shift in the characteristics of cancer incidence and mortality in China reminisces what happened in the United States. Although with the pressures of population aging (Karuturi et al., 2020), environmental pollution (White et al., 2021), and bad living habits (Kolb et al., 2016), the incidence and mortality rates of some cancers in the United States continue to decline, which is largely attributed to the devoted basic cancer research, efficient cancer prevention and treatment innovations in the United States. This suggests that China can refer to the measures taken by the United States on cancer prevention and treatment to come up with realistic solutions complying with the current situation of an aging population and challenging environmental problems in China to effectively reduce the cancer burden on society (Xia et al., 2022).

Difference in cancer burden between regions are gradually decreasing

China is a vast country with huge difference in living habits between different regions. And there is also difference in the level of economic development among regions. Therefore, there is clear variation in the type and incidence of cancer in each region (Yuan and Xie, 2021). Overall, South China has the highest ASIRW for cancer (204.3/100,000) and Southwest China (167.5/100,000) has the lowest ASIRW for cancer **(**Figure 3A**)**. Mortality rates also vary across regions. Overall, Central China had the highest ASMRW for cancer (112.0/100,000) and North China (94.5/100,000) had the lowest ASMRW for cancer (Figure 3B**)**.

In addition to the difference between regions, there are some differences in tumor incidence and mortality rates between urban and rural areas. The ASIRW for cancer is higher in urban areas (189.7/100,000) than in rural areas (176.2/100,000). The cancers with higher ASIRW in urban areas were lung cancer (36.7/100,000), female breast cancer (31.8/100,000), colorectal cancer (20.0/100,000), and prostate cancer (8.2/100,000) (Figure 4A). Whereas, cancers with higher ASIRW in rural areas are stomach cancer (19.8/100,000), liver cancer (19.3/100,000), cervical cancer (11.9/100,000), and esophagus cancer (15.0/100,000) (Figure 4B). The ASMRW for cancer was higher in rural areas (106.1/100,000) than in urban areas (102.8/100,000). Cancers with higher ASMRW in urban areas are lung cancer (28.0/100,000), colorectal cancer (9.0/100,000), female breast cancer (7.0/100,000), and prostate cancer (3.1/100,000)

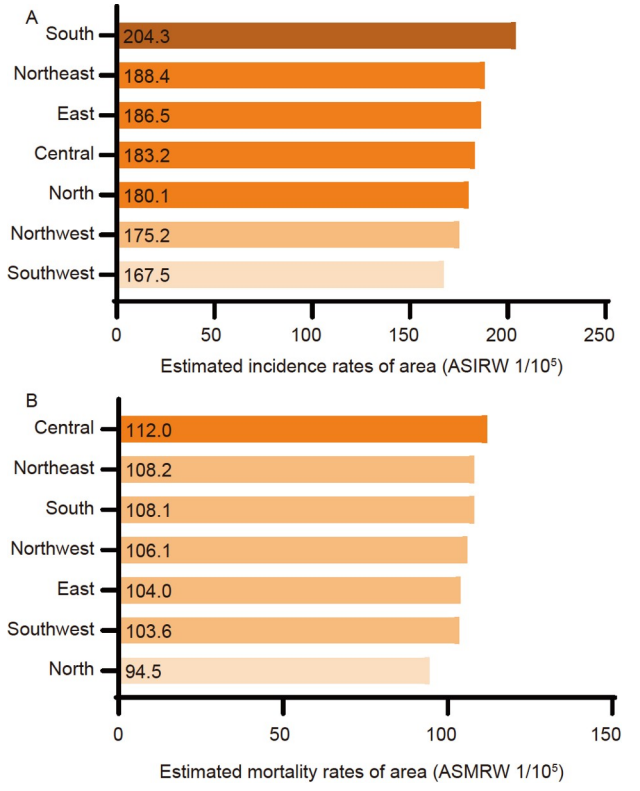

Figure 3 Cancer incidence and mortality rates in China by region. A, Cancer incidence rates in different regions of China. B, Cancer mortality rates in different regions of China.

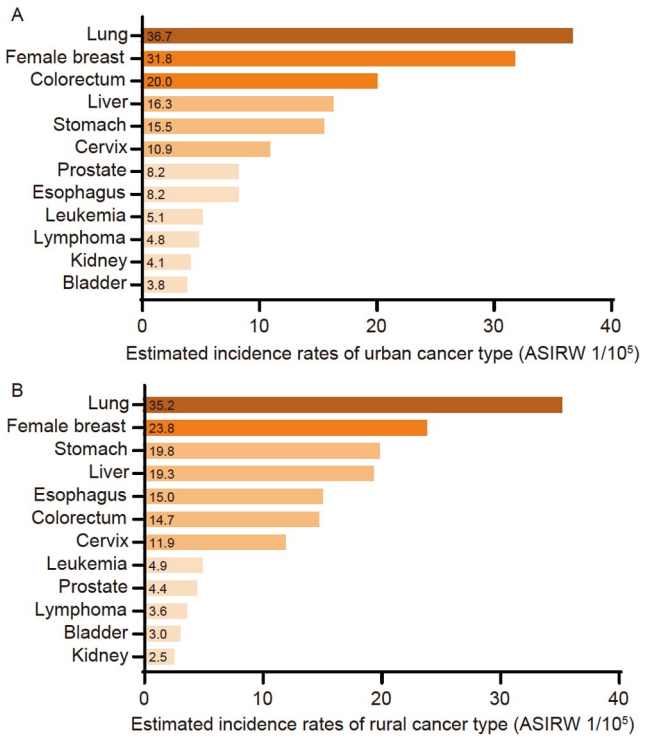

Figure 4 Cancer incidence rates in China by urban-rural. A, Twelve leading cancer types by incidence in urban areas. B, Twelve leading cancer types by incidence in rural areas.

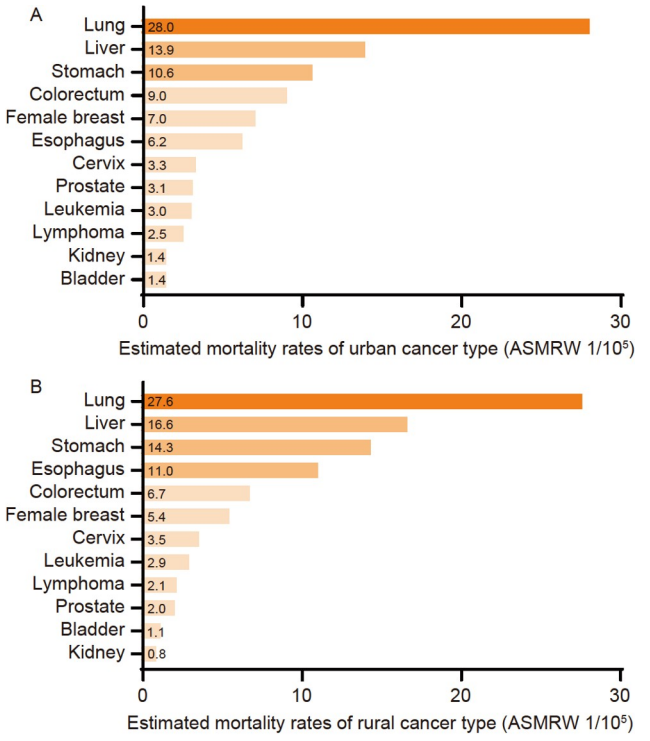

Figure 5 Cancer mortality rates in China by urban-rural. A, Twelve leading cancer types by mortality in urban areas. B, Twelve leading cancer types by mortality in rural areas.

(Figure 5A). Cancers with higher ASMRW in rural areas are liver cancer (16.6/100,000), stomach cancer (14.3/100,000), esophagus cancer (11.0/100,000), and cervical cancer (3.5/100,000) (Figure 5B).

Although there is currently a clear gap in morbidity and mortality rates between urban and rural areas, this discrepancy is gradually narrowing with the socioeconomic development. Some rural populations are gradually transforming into urban populations. Some risk factors of cancer including smoking, chronic infections, dietary habits, and air pollution are shared between urban and rural areas. The major reason for the high cancer incidence in urban areas is the different aging process of the population. The high cancer mortality rate in rural areas is closely associated with lacking of access to early diagnosis and treatment. To address these unequal risk factors, the government should develop appropriate prevention and treatment strategies for different populations.

Reasons for change of cancer incidence and mortality in china

Aging of the population

The risk of developing cancer increases with age (Zheng et al., 2022). The aging process of China's population accelerates after entering the 21st century. The elderly population aged 65 and above increased from 62.99 million in 1990 to 190.64 million in 2020, and accordingly the proportion to the total population increased from 5.57% to 13.50%. The latest cancer statistics shows that the incidence of cancer is very low between 0–14 years old regardless of gender, and increases gradually with age. The cancer incidence rate peaks at the age of 60–79 years. However, the incidence of cancer decreases after the age of 80 years and above (Figure 6A). The mortality rate of cancer in China displays the same trend (Figure 6B). Thus, an aging population will inevitably experience an increase in cancer incidence and mortality. In addition, the increasing cancer burden in China is partially due to the population aging during the past decades.

Interestingly, the study of the role of senescence in tumor pathogenesis finds that cellular senescence is a paradoxical process for tumorigenesis. Cellular senescence induces cells into a state of cell cycle arrest, which in turn inhibits tumor cell proliferation (Ogrodnik, 2021). However, in hematologic malignancies, senescent cells form a microenvironment suitable for tumor cell proliferation and survival by secreting a series of inflammatory cytokines, chemokines, growth factors and proteases, which ultimately promote tumorigenesis (Hu et al., 2021). Therefore, delineating the mechanisms of aging and tumorigenesis can provide new molecular targets and rational therapeutic strategies for cancer treatment of elderly patients.

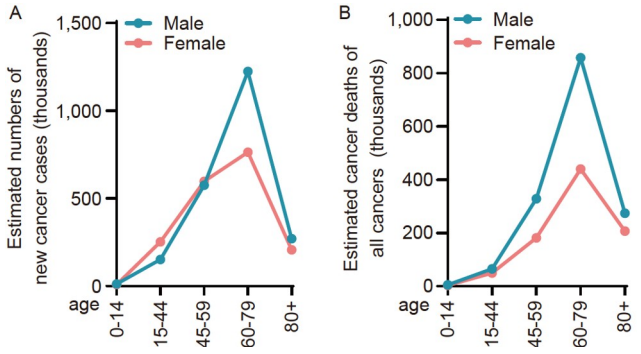

Figure 6 Cancer incidence and mortality rates in China by age and gender. A, Cancer incidence rates in China by age and gender. B, Cancer mortality rates in China by age and gender.

Environmental factors

The development of cancer is also closely linked to environmental factors (Yin et al., 2020). Environmental pollution accompanying the economic development has led to an increase in the incidence of many cancers (Ou et al., 2020). It was reported that 44.9% of male lung cancer and 86.1% of female lung cancer in China were not associated with smoking (Liang et al., 2019). Rather, they were closely linked to air pollution (Xue et al., 2022), cooking fumes (Chen et al., 2020), poor diet (Yang et al., 2020), and other factors (Li et al., 2021). A multicenter study conducted in North China confirmed the influence of these factors on the incidence of lung cancer (Liang et al., 2019). And the proportion of non-smoking patients with lung cancer increased from 31% in 1999–2002 to 48% in 2008–2011 (Toh et al., 2018), reconfirming that the environmental pollution accompanying the economic development is a key cancer risk factor. Changes in lifestyle led to a significant increase in the incidence of gastrointestinal (GI) tumors (Shao et al., 2018). In analysis of the causes of GI tumor incidence in China in 2011, it was found that 13.2% of GI tumor incidence was associated with smoking, 12.0% with red meat intake, 9.5% with body mass index (BMI) overload, and 6.4% with excessive alcohol intake. A prospective clinical study hypothesized that 56.5% of colorectal cancers, 48.5% of esophageal cancers, 59.8% of gastric cancers, and 35.2% of liver cancers could have been prevented if avoiding smoking and alcohol drinking, and eating a healthy diet such as reducing the intake of red meat and high sodium, and increasing fruit and vegetable consuming (Wu et al., 2021). In analysis of the relationship between viral infections and the development of GI tumors, it was found that 43.8% of liver cancers were associated with HBV and hepatitis C virus (HCV) infections, and 39.1% of gastric cancers were associated with Helicobacter pylori (HP) infection (Wu et al., 2021). In addition, Epstein-Barr virus (EBV) infection is strongly associated with the development of nasopharyngeal and some gastric cancers. Although the EBV virus is found worldwide, Southeast Asia, especially South China accounts for most of the global nasopharyngeal cancer cases. The reason for this is that the EBV subtype prevalent in South China is a high-risk type that will result in a more than six-fold increase in the incidence of nasopharyngeal cancer (Xu et al., 2019). Human papillomavirus (HPV) infection is closely associated with cervical cancer and is partially associated with anal, penile, vaginal, vulvar, oral, oropharyngeal, and laryngeal cancers. It was reported that 89.6% of cervical cancer incidence and deaths were associated with HPV in China from 2005 to 2015, and that HPV infection caused a significant increase in cancer incidence and mortality (Lu et al., 2020). Currently, the living environments and habits are changing rapidly along with the economic development, which leads to a steady shift of the incidence and mortality rates of different cancers in China.

Increased efforts on cancer prevention and treatment

The changes in morbidity and mortality of cancers in China are not only a direct reflection of the ageing population and the swift socio-economic development, but also closely associated with the increasing efforts of cancer prevention and treatment by the whole society. Since the discovery that some cancers are caused by viral infection, vaccination against viral infection efficiently lowered the incidence of these cancers (Khan and Savoy, 2020; Shi et al., 2021). For instance, vaccines against HBV and HPV have shown excellent results in preventing liver and cervical cancers (Wang et al., 2020; Xie, 2017). Vaccines targeting tumor-associated antigens (TAAs) are also effective (Wang et al., 2020), such as Sipuleucel-T, an autologous dendritic cell (DC) vaccine targeting prostatic acid phosphatase (PAP) for the treatment of prostate cancer (Cheever and Higano, 2011; Kantoff et al., 2010). In addition, vaccines targeting mutation-driven tumors have shown encouraging efficacy in animal studies (Ebben et al., 2016; Zhang et al., 2020). Cancer-associated vaccination is not only a measure to reduce the incidence of cancer in individuals with high genetic risk (Kloor et al., 2015), but also as a therapeutic modality to prevent the recurrence from residual cancer cells after surgery (Slingluff et al., 2020). In combination with immune checkpoint inhibitors such as anti-PD-1, vaccine therapy is used to improve the effectiveness of cancer treatment (Hong et al., 2018; Ott et al., 2020), which will have broad applications in the future (Enokida et al., 2021; Zhou et al., 2021)

With the breakthrough of biomedical research, cancer that was difficult to treat or even to diagnose in the past has now been treated in a standardized way. More and more new therapeutic modalities have been approved for use, among which immunotherapy has received increasing attention (Tan et al., 2020). Adoptive cell transfer (ACT) therapies such as

chimeric antigen receptor T-cell immunotherapy (CAR-T) have shown promising results in hematologic malignancies (Holstein and Lunning, 2020). Immune checkpoint inhibitors (ICIs) including anti-CTL-4 monoclonal antibody and anti-PD-1 monoclonal antibody have shown great efficacy in the treatment of a variety of tumors (Bagchi et al., 2021). In addition, nanomaterials also have broad applications in tumor therapy (Cheng et al., 2021). On the one hand, the characteristics of nanomaterials enable them to specifically target tumor tissues and kill tumor cells, while avoiding the damage to normal tissues (Zi et al., 2022). On the other hand, nanomaterials can be used as vectors to carry DNA (Zhang et al., 2020), RNA (Wang et al., 2021), drugs (Garbayo et al., 2020), proteins (Lin et al., 2021), or other active molecules (Zhao et al., 2020) to target tumor sites and play a role in enhancing therapeutic efficacy.

In addition, people in China are now paying more attention to their health than ever before. Changes of lifestyle and diet habits lowered the incidence of some cancers, while implementation of early cancer screening system enables early treatment with much better efficacy, which is an important reason for the decline of mortality rate for some cancers in China (Chan and Liang, 2022; Mutebi et al., 2020; Yang et al., 2021).

Strategies for cancer prevention and treatment in china

Cancer is one of the leading causes of death worldwide (Cao et al., 2021). Despite the decline of the incidence and mortality rates for some cancers in China recently, burden of cancer remains a huge challenge for the healthcare system of this country (Cao et al., 2020). With the shift of the incidence of different cancers in China gradually towards that of developed countries such as the United States (Siegel et al., 2022), it is urgent to establish a cancer prevention and treatment approach suitable for the changing situation in China with reference to cancer prevention and treatment experience from other countries (Xia et al., 2022).

Emphasizing on lifestyle change and cancer prevention

Cancer with the highest incidence and mortality rates in China is lung cancer, which is closely associated with smoking and alcohol consumption. There are over 300 million smokers and 700 million passive smokers in China (Wan, 2022; Xie et al., 2021a). The reduction of lung cancer incidence by tobacco control in developed countries has shown affirmative results (Ganti et al., 2021). Therefore, encouraging smoking quitting, banning smoking in public, and early screening for high-risk population should be a policy priority to reduce the incidence and mortality of lung cancer. For digestive tract cancers, on the one hand, it is important to improve the diet structure, avoiding high-calorie, high-fat, and low-fiber foods, and to strengthen exercise to avoid metabolic disorders caused by obesity, which is an inducer of cancer; on the other hand, it is imperative to avoid moldy or overnight food which containing excessive aflatoxin or nitrosamines, to quit betel nut chewing (Yang et al., 2021) and tobacco consuming, and to reduce alcohol drinking (Rumgay et al., 2021). For tumors caused by viral infections, vaccination and cutting off transmission are equally important (Brisson et al., 2020; Dundar et al., 2022). The government should advocate and raise the awareness of cancer prevention in general population to reduce the chance of malignant transformation in various ways.

Early screening

Patients with advanced cancer not only have *in situ* infiltration but also have distant metastases which worsen the outcome (Ganesh and Massagué, 2021). Current treatment for early-stage cancer is highly effective, with 5-year survival rate as high as 90% (Pui, 2020; Tellez-Gabriel et al., 2020; van den Berg et al., 2021; Yang and Heimbach, 2020). In contrast, the outcome for patients with advanced cancers is poor and the mortality rate is high. Therefore, early screening and diagnosis in high prevalence areas and in high-risk groups are vital to reduce the burden of cancer (Crosby et al., 2022). There are various means of early screening for tumors. Ultrasound monitoring of the thyroid gland can effectively lower the mortality rate of thyroid cancer (Kant et al., 2020). Gastroscopy to assess risk of gastric cancer (Young et al., 2021). Fecal occult blood test (Lee et al., 2020), fecal immunochemical test (Robertson and Selby, 2020), flexible sigmoidoscopy or colonoscopy (Cox et al., 2020; Grobbee et al., 2020) to prevent colorectal cancer deteriorate. Chest X-ray (Bradley et al., 2021) and low-dose computed tomography (LDCT) to detect lung cancer in the early stage (Oudkerk et al., 2021) and mammography to prevent female breast cancer (Lotter et al., 2021). Molecular markers are also important references for early cancer diagnosis. Alpha-fetoprotein (AFP) is used for the early diagnosis of primary liver cancer (Zhao et al., 2022). Prostate specific antigen (PSA) is used for the early detection of prostate cancer (Carlsson and Vickers, 2020). Carcinoembryonic antigen (CEA) is used as an indicator of gastrointestinal tumors (Gago et al., 2021; Gulhati et al., 2020). Genetic screening is beneficial for assessment of risk among susceptible populations, for instance *BRCA1*/*2* gene testing is employed to predict the risk of breast or ovarian cancer (Su et al., 2021). The government should vigorously advertise the importance of early screening and encourage high risk populations to pay attention to their own health and undergo regular medical checkups. In addition, the government

should also prioritize perfecting the primary healthcare screening system, train more community doctors to meet that need, and organize regular screening accordingly in areas with high prevalence of cancers.

Standardized treatment

With the increasing understanding of tumor pathogenesis, options for the cancer treatment are gradually increasing, and they are different for different subtypes of cancers. For example, different subtypes of female breast cancer are treated in different ways (Kunte et al., 2020; Tsang and Tse, 2020). Cancer cells can evade the body's immune surveillance (Mao et al., 2021), and the occurrence of immune escape is an important reason why cancer progress rapidly and are difficult to cure (Fan et al., 2021). With the unveiling of some import mechanisms of tumor immune escape, cancer immunotherapy is now widely used in clinical practice (Ge et al., 2021; Wang et al., 2022). Among them, inhibitors targeting PD-1/PD-L1 and CTLA-4 immune checkpoints have shown impressive efficacy clinically (Hudson et al., 2020; Willsmore et al., 2021). Some difficult-to-treat cancers also have shown improved survival rate (Ti et al., 2021). However, the treatment modality for common cancers should be standardized to improve the efficacy and to avoid overtreatment, such that the economic and social burden can be alleviated (Dilalla et al., 2020). For the economically less developed areas, strengthening the training of doctors is also an effective way to improve the treatment efficacy.

Promoting cancer-relevant basic research

The continuous improvement of cancer prevention and treatment in China is indispensable from the breakthroughs in basic research on cancer pathogenesis. The successful early cancer diagnosis largely depends on the revelation of key molecules or processes that play important roles in the development of tumors (Nault and Villanueva, 2021). Circular RNAs (circRNAs) are a class of non-coding RNA, exist stably in various cells (Fan et al., 2021; Mo et al., 2021; Saw et al., 2021; Tang et al., 2021), which can be secreted extracellularly and to be detected in body fluids (Wang et al., 2021). Since circRNAs are widely involved in the malignant progression of cancers (Xue et al., 2021), circRNAs are potential molecular targets for early diagnosis of cancer (Ghafouri-Fard et al., 2021). In addition to circRNAs, other molecules that play pivotal roles in carcinogenesis and have altered expressions are also potential targets in cancer diagnosis and risk evaluation (Xu et al., 2020). Of note, the use of liquid biopsy for cancer diagnosis is a new focus of research and application (Heidrich et al., 2021).

The development of anti-tumor drugs is also an important part of basic oncology research. Exploring the mechanisms of resistance to classical chemotherapy will help to optimize current treatment modalities. This will help ease the financial strain and reduce side effects of cancer treatment (Zhu and Lin, 2021). In addition, combinational therapy is currently an important means to improve the efficiency of cancer treatment (Li et al., 2021; Wei et al., 2021; Zhang et al., 2020; Zhu et al., 2021). With the emergence of novel therapeutic modalities such as immunotherapy and nanomedicine, the efficacy of cancer therapy significantly enhanced.

However, lacks of precision and harmful side-effects are important challenges for optimizing cancer therapy at present (Hua et al., 2021). Researchers should take full advantage of our rich clinical resources, advanced experimental techniques, and big cohort data to identify biomarkers that can substantially benefit early cancer screening. Research institutions should orchestrate multicenter clinical studies to establish and verify the rationality and validity of new biomarkers and novel cancer treatment modalities (Gu et al., 2022). To achieve the purpose of precision cancer treatment, researchers should continue to investigate the mechanism of immune escape by tumor cells, and establish comprehensive database of tumor neoantigens and explore the potential role of neoantigens in cancer vaccination (De Mattos-Arruda et al., 2020; Wang et al., 2022).

In addition, with the development of bioinformatics, predictive models based on big data have received more and more attention. On the one hand, it can perform cancer risk prediction through comprehensive analysis of molecular targets (Lee et al., 2022). On the other hand, cancer patient's diagnostic results can be analyzed comprehensively to assess the potential of tumor progression and metastasis, and to provide information for individualized treatment and minimize unnecessary surgery and postoperative complications (Jiang et al., 2021). Multidisciplinary collaboration also holds great promise for improving cancer diagnosis and treatment.

Prospects

Although the overall incidence and mortality rates of cancer in China are still on the rise, the incidence and mortality rates for some tumors have been decreasing, and the survival rates of some cancers continue to increase. This indicates that the current strategies targeting cancer prevention and treatment show initial effect. However, with the presence of an aging population and poor diet habits, we still cannot slacken our efforts on cancer prevention and treatment in the future (Yang et al., 2020).

With the socio-economic development, the cancer incidence spectrum in China is gradually approaching that of developed countries. And the incidence and mortality rates of some cancers in developed countries such as the United

States have continued to decline in recent years. This suggests that some of their cancer control strategies, such as tobacco control, early screening, standardized treatment and patient care, can be adopted by us to effectively reduce the cancer burden (Xia et al., 2022).

In addition, basic research in developed countries has revealed much of the mechanism of tumor pathogenesis and drug resistance. The research results are being translated into clinical practice. A variety of targeted drugs and immune checkpoint inhibitors have been developed and have achieved good results clinically. Therefore, researchers in China should also vigorously promote tumor-related basic research, explore molecular targets for early diagnosis and develop targeted drugs for tumor treatment based on our needs.

The rising incidence of cancer in China is not only linked to population ageing, but also associated with the current advanced diagnostic methods. The incidence of thyroid cancer is high, but the mortality rate remains stable (Wu et al., 2022). This is because advanced screening has detected many early-stage microscopic thyroid cancers (Xie et al., 2021b). The treatment of this part of the cancer patients should, on the one hand, try to ensure the health of the patients and their quality of life; and on the other hand, it is also necessary to avoid wasting of resource and increasing social burden caused by excessive medical intervention. In addition, under the influence of COVID-19, China is facing new challenges in cancer prevention and treatment (Liu et al., 2020).

Compliance and ethics *The authors declare that they have no conflict of interest.*

Acknowledgements *This work was supported by the National Natural Science Foundation of China (U21A20382, U20A20367, 82072374), the Overseas Expertise Introduction Project for Discipline Innovation (BP1221008) and the Natural Science Foundation of Hunan Province (2021JJ30897, 2021JJ41043).*

References

Alipour, M. (2021). Molecular mechanism of helicobacter pylori-induced gastric cancer. J Gastrointest Canc 52, 23–30.

Avgerinos, K.I., Spyrou, N., Mantzoros, C.S., and Dalamaga, M. (2019). Obesity and cancer risk: emerging biological mechanisms and perspectives. Metabolism 92, 121–135.

Bagchi, S., Yuan, R., and Engleman, E.G. (2021). Immune checkpoint inhibitors for the treatment of cancer: clinical impact and mechanisms of response and resistance. Annu Rev Pathol Mech Dis 16, 223–249.

Bradley, S.H., Hatton, N.L.F., Aslam, R., Bhartia, B., Callister, M.E., Kennedy, M.P., Mounce, L.T., Shinkins, B., Hamilton, W.T., and Neal, R.D. (2021). Estimating lung cancer risk from chest X-ray and symptoms: a prospective cohort study. Br J Gen Pract 71, e280–e286.

Brisson, M., Kim, J.J., Canfell, K., Drolet, M., Gingras, G., Burger, E.A., Martin, D., Simms, K.T., Bénard, É., Boily, M.C., et al. (2020). Impact of HPV vaccination and cervical screening on cervical cancer elimination: a comparative modelling analysis in 78 low-income and lower-middle-income countries. Lancet 395, 575–590.

Cao, M., Li, H., Sun, D., and Chen, W. (2020). Cancer burden of major cancers in China: a need for sustainable actions. Cancer Commun 40, 205–210.

Cao, W., Chen, H.D., Yu, Y.W., Li, N., and Chen, W.Q. (2021). Changing profiles of cancer burden worldwide and in China: a secondary analysis of the global cancer statistics 2020. Chin Med J 134, 783–791.

Carlsson, S.V., and Vickers, A.J. (2020). Screening for prostate cancer. Med Clin N Am 104, 1051–1062.

Chan, S.C.H., and Liang, J.Q. (2022). Advances in tests for colorectal cancer screening and diagnosis. Expert Rev Mol Diag 22, 449–460.

Chang, M.H. (2021). Prevention of hepatitis B virus infection and liver cancer. Recent Results Cancer Res 217, 71–90.

Cheever, M.A., and Higano, C.S. (2011). PROVENGE (Sipuleucel-T) in prostate cancer: the first FDA-approved therapeutic cancer vaccine. Clin Cancer Res 17, 3520–3526.

Chen, C.P. (2020). Role of external beam radiotherapy in hepatocellular carcinoma. Clin Liver Dis 24, 701–717.

Chen, T.Y., Fang, Y.H., Chen, H.L., Chang, C.H., Huang, H., Chen, Y.S., Liao, K.M., Wu, H.Y., Chang, G.C., Tsai, Y.H., et al. (2020). Impact of cooking oil fume exposure and fume extractor use on lung cancer risk in non-smoking Han Chinese women. Sci Rep 10, 6774.

Chen, W., Sun, K., Zheng, R., Zeng, H., Zhang, S., Xia, C., Yang, Z., Li, H., Zou, X., and He, J. (2018). Cancer incidence and mortality in China, 2014. Chin J Cancer Res 30, 1–12.

Chen, Y., Yang, C., Li, N., Wang, Z., Wu, P., Du, J., and Jiang, J. (2022). Effects of population aging on the mortality burden of related cancers in urban and rural areas of China, 2004–2017: a population-based study. Cancer Biol Med 19, 696–706.

Chen, Z., Ma, Y., Hua, J., Wang, Y., and Guo, H. (2021). Impacts from economic development and environmental factors on life expectancy: a comparative study based on data from both developed and developing countries from 2004 to 2016. Int J Environ Res Public Health 18, 8559.

Cheng, Z., Li, M., Dey, R., and Chen, Y. (2021). Nanomaterials for cancer therapy: current progress and perspectives. J Hematol Oncol 14, 85.

Cox, B., Sneyd, M.J., Hingston, G., McBride, D., and Bagshaw, P.F. (2020). Enhancing bowel screening: preventing colorectal cancer by flexible sigmoidoscopy in New Zealand. Public Health 179, 27–37.

Crosby, D., Bhatia, S., Brindle, K.M., Coussens, L.M., Dive, C., Emberton, M., Esener, S., Fitzgerald, R.C., Gambhir, S.S., Kuhn, P., et al. (2022). Early detection of cancer. Science 375, eaay9040.

De Mattos-Arruda, L., Vazquez, M., Finotello, F., Lepore, R., Porta, E., Hundal, J., Amengual-Rigo, P., Ng, C.K.Y., Valencia, A., Carrillo, J., et al. (2020). Neoantigen prediction and computational perspectives towards clinical benefit: recommendations from the ESMO Precision Medicine Working Group. Ann Oncol 31, 978–990.

Dilalla, V., Chaput, G., Williams, T., and Sultanem, K. (2020). Radiotherapy side effects: integrating a survivorship clinical lens to better serve patients. Curr Oncol 27, 107–112.

Dundar, Y., Eldem, I., Schwartz, C., Pomeroy, L., Cordero, J., Arslan, O., and Levent, F. (2022). Screening awareness of HPV-related oropharyngeal cancers and attitudes and concerns towards HPV vaccination among parents. J Canc Educ 37, 1152–1160.

Ebben, J.D., Lubet, R.A., Gad, E., Disis, M.L., and You, M. (2016). Epidermal growth factor receptor derived peptide vaccination to prevent lung adenocarcinoma formation: An *in vivo* study in a murine model of EGFR mutant lung cancer. Mol Carcinog 55, 1517–1525.

Enokida, T., Moreira, A., and Bhardwaj, N. (2021). Vaccines for immunoprevention of cancer. J Clin Invest 131, e146956.

Fan, C., Qu, H., Xiong, F., Tang, Y., Tang, T., Zhang, L., Mo, Y., Li, X., Guo, C., Zhang, S., et al. (2021). CircARHGAP12 promotes nasopharyngeal carcinoma migration and invasion via ezrin-mediated cytoskeletal remodeling. Cancer Lett 496, 41–56.

Fan, C., Zhang, S., Gong, Z., Li, X., Xiang, B., Deng, H., Zhou, M., Li, G., Li, Y., Xiong, W., et al. (2021). Emerging role of metabolic reprogramming in tumor immune evasion and immunotherapy. Sci China Life Sci 64, 534–547.

Feng, R.M., Zong, Y.N., Cao, S.M., and Xu, R.H. (2019). Current cancer situation in China: good or bad news from the 2018 Global Cancer Statistics? Cancer Commun 39, 22.
Gago, T., Caldeira, P., Cunha, C., Campelo, P., and Guerreiro, H. (2021). Can we optimize the CEA as a response marker in rectal cancer? Rev Esp Enferm Dig 113, 423–428.
Ganesh, K., and Massagué, J. (2021). Targeting metastatic cancer. Nat Med 27, 34–44.
Ganti, A.K., Klein, A.B., Cotarla, I., Seal, B., and Chou, E. (2021). Update of incidence, prevalence, survival, and initial treatment in patients with non-small cell lung cancer in the US. JAMA Oncol 7, 1824–1832.
Garbayo, E., Pascual-Gil, S., Rodríguez-Nogales, C., Saludas, L., Estella-Hermoso de Mendoza, A., and Blanco-Prieto, M.J. (2020). Nanomedicine and drug delivery systems in cancer and regenerative medicine. WIREs Nanomed Nanobiotechnol 12, e1637.
Ge, J., Wang, J., Xiong, F., Jiang, X., Zhu, K., Wang, Y., Mo, Y., Gong, Z., Zhang, S., He, Y., et al. (2021). Epstein-barr virus-encoded circular RNA CircBART2.2 promotes immune escape of nasopharyngeal carcinoma by regulating PD-L1. Cancer Res 81, 5074–5088.
Ghafouri-Fard, S., Honarmand Tamizkar, K., Jamali, E., Taheri, M., and Ayatollahi, S.A. (2021). Contribution of circRNAs in gastric cancer. Pathol-Res Pract 227, 153640.
Grobbee, E.J., van der Vlugt, M., van Vuuren, A.J., Stroobants, A.K., Mallant-Hent, R.C., Lansdorp-Vogelaar, I., Bossuyt, P.M.M., Kuipers, E.J., Dekker, E., and Spaander, M.C.W. (2020). Diagnostic yield of one-time colonoscopy vs. one-time flexible sigmoidoscopy vs multiple rounds of mailed fecal immunohistochemical tests in colorectal cancer screening. Clin Gastroenterol Hepatol 18, 667–675.e1.
Gu, X., Zheng, S., Zhang, H., Sun, X., and Zhou, Q. (2022). The cross-talk of cancer-associated fibroblasts assist in prognosis and immunotherapy in patients with breast carcinoma. Cancer Gene Ther 29, 2001–2012.
Gulhati, P., Yin, J., Pederson, L., Schmoll, H.J., Hoff, P., Douillard, J.Y., Hecht, J.R., Tournigand, C., Tebbut, N., Chibaudel, B., et al. (2020). Threshold change in CEA as a predictor of non-progression to first-line systemic therapy in metastatic colorectal cancer patients with elevated CEA. J Natl Cancer Inst 112, 1127–1136.
Harbeck, N., Rastogi, P., Martin, M., Tolaney, S.M., Shao, Z.M., Fasching, P.A., Huang, C.S., Jaliffe, G.G., Tryakin, A., Goetz, M.P., et al. (2021). Adjuvant abemaciclib combined with endocrine therapy for high-risk early breast cancer: updated efficacy and Ki-67 analysis from the monarchE study. Ann Oncol 32, 1571–1581.
Heidrich, I., Ačkar, L., Mossahebi Mohammadi, P., and Pantel, K. (2021). Liquid biopsies: potential and challenges. Int J Cancer 148, 528–545.
Holstein, S.A., and Lunning, M.A. (2020). CAR T-cell therapy in hematologic malignancies: a voyage in progress. Clin Pharmacol Ther 107, 112–122.
Hong, M., Tang, K., Qian, J., Deng, H., Zeng, M., Zheng, S., Ding, K., Du, Y., and Sun, R. (2018). Immunotherapy for EBV-associated nasopharyngeal carcinoma. Crit Rev Oncog 23, 219–234.
Hu, D., Yuan, S., Zhong, J., Liu, Z., Wang, Y., Liu, L., Li, J., Wen, F., Liu, J., and Zhang, J. (2021). Cellular senescence and hematological malignancies: from pathogenesis to therapeutics. Pharmacol Ther 223, 107817.
Hua, H., Zhang, H., Chen, J., Wang, J., Liu, J., and Jiang, Y. (2021). Targeting Akt in cancer for precision therapy. J Hematol Oncol 14, 128.
Hudson, K., Cross, N., Jordan-Mahy, N., and Leyland, R. (2020). The extrinsic and intrinsic roles of PD-L1 and its receptor PD-1: implications for immunotherapy treatment. Front Immunol 11, 568931.
Jeon, J., Holford, T.R., Levy, D.T., Feuer, E.J., Cao, P., Tam, J., Clarke, L., Clarke, J., Kong, C.Y., and Meza, R. (2018). Smoking and lung cancer mortality in the United States from 2015 to 2065. Ann Intern Med 169, 684–693.
Jiang, Y., Liang, X., Wang, W., Chen, C., Yuan, Q., Zhang, X., Li, N., Chen, H., Yu, J., Xie, Y., et al. (2021). Noninvasive prediction of occult peritoneal metastasis in gastric cancer using deep learning. JAMA Netw Open 4, e2032269.
Kant, R., Davis, A., and Verma, V. (2020). Thyroid Nodules: advances in evaluation and management. Am Family Phys 102, 298–304.
Kantoff, P.W., Higano, C.S., Shore, N.D., Berger, E.R., Small, E.J., Penson, D.F., Redfern, C.H., Ferrari, A.C., Dreicer, R., Sims, R.B., et al. (2010). Sipuleucel-T immunotherapy for castration-resistant prostate cancer. N Engl J Med 363, 411–422.
Karuturi, M.S., Sedrak, M.S., Magnuson, A., Freedman, R., Jatoi, A., Smith, B.D., and Kimmick, G.G. (2020). Breast cancer and aging: standing on the shoulders of a giant. J Geriatr Oncol 11, 212–216.
Key, T. (1995). Hormones and cancer in humans. Mutat Res Fund Mol Mech Mut 333, 59–67.
Khan, M.S., and Savoy, M. (2020). Impact of human papillomavirus vaccination in reducing cancer. Prim Care 47, 529–537.
Kloor, M., Reuschenbach, M., Karbach, J., Rafiyan, M., Al-Batran, S.E., Pauligk, C., Jaeger, E., and von Knebel Doeberitz, M. (2015). Vaccination of MSI-H colorectal cancer patients with frameshift peptide antigens: a phase I/IIa clinical trial. J Clin Oncol 33, 3020.
Kolb, R., Sutterwala, F.S., and Zhang, W. (2016). Obesity and cancer: inflammation bridges the two. Curr Opin Pharmacol 29, 77–89.
Krajewska, J., Kukulska, A., Oczko-Wojciechowska, M., Kotecka-Blicharz, A., Drosik-Rutowicz, K., Haras-Gil, M., Jarzab, B., and Handkiewicz-Junak, D. (2020). Early diagnosis of low-risk papillary thyroid cancer results rather in overtreatment than a better survival. Front Endocrinol 11, 571421.
Kunte, S., Abraham, J., and Montero, A.J. (2020). Novel HER2-targeted therapies for HER2-positive metastatic breast cancer. Cancer 126, 4278–4288.
Lee, M.W., Pourmorady, J.S., and Laine, L. (2020). Use of fecal occult blood testing as a diagnostic tool for clinical indications: a systematic review and meta-analysis. Am J Gastroenterol 115, 662–670.
Lee, Y.J., Park, J.H., and Lee, S.H. (2022). A study on the prediction of cancer using whole-genome data and deep learning. Int J Mol Sci 23, 10396.
Legler, J.M., Feuer, E.J., Potosky, A.L., Merrill, R.M., and Kramer, B.S. (1998). The role of prostate-specific antigen (PSA) testing patterns in the recent prostate cancer incidence decline in the United States. Cancer Causes Control 9, 519–527.
Li, K., Zhang, A., Li, X., Zhang, H., and Zhao, L. (2021). Advances in clinical immunotherapy for gastric cancer. Biochim Biophys Acta 1876, 188615.
Li, C.L., Shao, C.M., He, C.X., Ren, C.S., and Tian, C.T. (2021). Risk of lung cancer due to external environmental factor and epidemiological data analysis. Math Biosci Eng 18, 6079–6094.
Liang, D., Wang, J., Li, D., Shi, J., Jing, J., Shan, B., and He, Y. (2019). Lung cancer in never-smokers: a multicenter case-control study in North China. Front Oncol 9, 1354.
Lin, Y.S., Chen, Y., Tsai, Y.H., Tseng, S.H., and Lin, K.S. (2021). *In vivo* imaging of neuroblastomas using GD2-targeting graphene quantum dots. J Pediatr Surg 56, 1227–1232.
Liu, C., Zhao, Y., Okwan-Duodu, D., Basho, R., and Cui, X. (2020). COVID-19 in cancer patients: risk, clinical features, and management. Cancer Biol Med 17, 519–527.
Lotter, W., Diab, A.R., Haslam, B., Kim, J.G., Grisot, G., Wu, E., Wu, K., Onieva, J.O., Boyer, Y., Boxerman, J.L., et al. (2021). Robust breast cancer detection in mammography and digital breast tomosynthesis using an annotation-efficient deep learning approach. Nat Med 27, 244–249.
Lu, Y., Li, P., Luo, G., Liu, D., and Zou, H. (2020). Cancer attributable to human papillomavirus infection in China: burden and trends. Cancer 126, 3719–3732.
Machlowska, J., Baj, J., Sitarz, M., Maciejewski, R., and Sitarz, R. (2020). Gastric cancer: epidemiology, risk factors, classification, genomic characteristics and treatment strategies. Int J Mol Sci 21, 4012.
Mao, X., Xu, J., Wang, W., Liang, C., Hua, J., Liu, J., Zhang, B., Meng, Q., Yu, X., and Shi, S. (2021). Crosstalk between cancer-associated fibroblasts and immune cells in the tumor microenvironment: new findings and future perspectives. Mol Cancer 20, 131.
Miranda-Galvis, M., Loveless, R., Kowalski, L.P., and Teng, Y. (2021).

Impacts of environmental factors on head and neck cancer pathogenesis and progression. Cells 10, 389.
Mo, Y., Wang, Y., Zhang, S., Xiong, F., Yan, Q., Jiang, X., Deng, X., Wang, Y., Fan, C., Tang, L., et al. (2021). Circular RNA circRNF13 inhibits proliferation and metastasis of nasopharyngeal carcinoma via SUMO2. Mol Cancer 20, 112.
Mutebi, M., Anderson, B.O., Duggan, C., Adebamowo, C., Agarwal, G., Ali, Z., Bird, P., Bourque, J.M., DeBoer, R., Gebrim, L.H., et al. (2020). Breast cancer treatment: a phased approach to implementation. Cancer 126, 2365–2378.
Nault, J.C., and Villanueva, A. (2021). Biomarkers for hepatobiliary cancers. Hepatology 73, 115–127.
Ogrodnik, M. (2021). Cellular aging beyond cellular senescence: markers of senescence prior to cell cycle arrest *in vitro* and *in vivo*. Aging Cell 20, e13338.
Ott, P.A., Hu-Lieskovan, S., Chmielowski, B., Govindan, R., Naing, A., Bhardwaj, N., Margolin, K., Awad, M.M., Hellmann, M.D., Lin, J.J., et al. (2020). A phase Ib trial of personalized neoantigen therapy plus anti-PD-1 in patients with advanced melanoma, non-small cell lung cancer, or bladder cancer. Cell 183, 347–362.e24.
Ou, J.Y., Kirchhoff, A.C., and Hanson, H.A. (2020). Air pollution across the cancer continuum: extending our understanding of the relationship between environmental exposures and cancer. Cancer Epidemiol Biomarkers Prev 29, 1876–1879.
Oudkerk, M., Liu, S.Y., Heuvelmans, M.A., Walter, J.E., and Field, J.K. (2021). Lung cancer LDCT screening and mortality reduction—evidence, pitfalls and future perspectives. Nat Rev Clin Oncol 18, 135–151.
Pacek, L.R., and McClernon, F.J. (2018). Decline in the perceived risk of cigarette smoking between 2006 and 2015: findings from a U.S. nationally representative sample. Drug Alcohol Depend 185, 406–410.
Phillips, E., Wang, T.W., Husten, C.G., Corey, C.G., Apelberg, B.J., Jamal, A., Homa, D.M., and King, B.A. (2017). Tobacco product use among adults—United States, 2015. MMWR Morb Mortal Wkly Rep 66, 1209–1215.
Poorolajal, J., Moradi, L., Mohammadi, Y., Cheraghi, Z., and Gohari-Ensaf, F. (2020). Risk factors for stomach cancer: a systematic review and meta-analysis. Epidemiol Health 42, e2020004.
Pui, C.H. (2020). Precision medicine in acute lymphoblastic leukemia. Front Med 14, 689–700.
Robertson, D.J., and Selby, K. (2020). Fecal immunochemical test: the world's colorectal cancer screening test. Gastrointest Endosc Clin N Am 30, 511–526.
Rumgay, H., Murphy, N., Ferrari, P., and Soerjomataram, I. (2021). Alcohol and cancer: epidemiology and biological mechanisms. Nutrients 13, 3173.
Saw, P.E., Xu, X., Chen, J., and Song, E.W. (2021). Non-coding RNAs: the new central dogma of cancer biology. Sci China Life Sci 64, 22–50.
Schiller, J.T., and Lowy, D.R. (2021). An introduction to virus infections and human cancer. Recent Results Cancer Res 217, 1–11.
Shao, Y., Hua, Z., Zhao, L., Shen, Y., Guo, X., Niu, C., Wei, W., and Liu, F. (2018). Time trends of gastrointestinal cancers incidence and mortality in Yangzhong from 1991 to 2015: an updated age-period-cohort analysis. Front Oncol 8, 638.
Shi, J.-., Cao, M., Wang, Y., Bai, F.-., Lei, L., Peng, J., Feletto, E., Canfell, K., Qu, C., and Chen, W. (2021). Is it possible to halve the incidence of liver cancer in China by 2050? Int J Cancer 148, 1051–1065.
Siegel, R.L., Miller, K.D., Fuchs, H.E., and Jemal, A. (2022). Cancer statistics, 2022. CA Cancer J Clin 72, 7–33.
Slingluff, C.L., Blumenstein, B.A., Lewis, K.D., Andtbacka, R.H.I., Hyngstrom, J.R., Milhem, M.M., Markovic, S., Hamid, O., Hernandez-Aya, L.F., Bowles, T.L., et al. (2020). Final analysis of relapse-free survival in a multicenter, double-blind, placebo-controlled trial of seviprotimut-L polyvalent melanoma vaccine after resection of high-risk melanoma. J Clin Oncol 38, 10017.
Su, Y., Yao, Q., Xu, Y., Yu, C., Zhang, J., Wang, Q., Li, J., Shi, D., Yu, B., Zeng, Y., et al. (2021). Characteristics of germline non-BRCA mutation status of high-risk breast cancer patients in China and correlation with high-risk factors and multigene testing suggestions. Front Genet 12, 674094.
Sun, D., Li, H., Cao, M., He, S., Lei, L., Peng, J., and Chen, W. (2020). Cancer burden in China: trends, risk factors and prevention. Cancer Biol Med 17, 879–895.
Syed, Y.Y. (2020). Sacituzumab govitecan: first approval. Drugs 80, 1019–1025.
Tan, S., Li, D., and Zhu, X. (2020). Cancer immunotherapy: pros, cons and beyond. Biomed Pharmacother 124, 109821.
Tang, L., Xiong, W., Zhang, L., Wang, D., Wang, Y., Wu, Y., Wei, F., Mo, Y., Hou, X., Shi, L., et al. (2021). circSETD3 regulates MAPRE1 through miR-615-5p and miR-1538 sponges to promote migration and invasion in nasopharyngeal carcinoma. Oncogene 40, 307–321.
Tchkonia, T., Palmer, A.K., and Kirkland, J.L. (2021). New horizons: novel approaches to enhance healthspan through targeting cellular senescence and related aging mechanisms. J Clin Endocrinol Metab 106, e1481–e1487.
Tellez-Gabriel, M., Knutsen, E., and Perander, M. (2020). Current status of circulating tumor cells, circulating tumor DNA, and exosomes in breast cancer liquid biopsies. Int J Mol Sci 21, 9457.
Ti, D., Bai, M., Li, X., Wei, J., Chen, D., Wu, Z., Wang, Y., and Han, W. (2021). Adaptive T cell immunotherapy in cancer. Sci China Life Sci 64, 363–371.
Toh, C.K., Ong, W.S., Lim, W.T., Tan, D.S.W., Ng, Q.S., Kanesvaran, R., Seow, W.J., Ang, M.K., and Tan, E.H. (2018). A decade of never-smokers among lung cancer patients—increasing trend and improved survival. Clin Lung Cancer 19, e539–e550.
Tsang, J.Y.S., and Tse, G.M. (2020). Molecular classification of breast cancer. Adv Anatom Pathol 27, 27–35.
Uhlenhopp, D.J., Then, E.O., Sunkara, T., and Gaduputi, V. (2020). Epidemiology of esophageal cancer: update in global trends, etiology and risk factors. Clin J Gastroenterol 13, 1010–1021.
van den Berg, I., Coebergh van den Braak, R.R.J., van Vugt, J.L.A., Ijzermans, J.N.M., and Buettner, S. (2021). Actual survival after resection of primary colorectal cancer: results from a prospective multicenter study. World J Surg Onc 19, 96.
Wan, X. (2022). Protecting people from tobacco smoke in China: current status and challenges. China CDC Weekly 4, 460–464.
Wang, G., Qiu, M., Xing, X., Zhou, J., Yao, H., Li, M., Yin, R., Hou, Y., Li, Y., Pan, S., et al. (2022). Lung cancer scRNA-seq and lipidomics reveal aberrant lipid metabolism for early-stage diagnosis. Sci Transl Med 14, eabk2756.
Wang, H., Ellipilli, S., Lee, W.J., Li, X., Vieweger, M., Ho, Y.S., and Guo, P. (2021). Multivalent rubber-like RNA nanoparticles for targeted co-delivery of paclitaxel and MiRNA to silence the drug efflux transporter and liver cancer drug resistance. J Control Release 330, 173–184.
Wang, J., Ge, J., Wang, Y., Xiong, F., Guo, J., Jiang, X., Zhang, L., Deng, X., Gong, Z., Zhang, S., et al. (2022). EBV miRNAs BART11 and BART17-3p promote immune escape through the enhancer-mediated transcription of PD-L1. Nat Commun 13, 866.
Wang, Q.T., Nie, Y., Sun, S.N., Lin, T., Han, R.J., Jiang, J., Li, Z., Li, J.Q., Xiao, Y.P., Fan, Y.Y., et al. (2020). Tumor-associated antigen-based personalized dendritic cell vaccine in solid tumor patients. Cancer Immunol Immunother 69, 1375–1387.
Wang, R., Pan, W., Jin, L., Huang, W., Li, Y., Wu, D., Gao, C., Ma, D., and Liao, S. (2020). Human papillomavirus vaccine against cervical cancer: opportunity and challenge. Cancer Lett 471, 88–102.
Wang, S., Zhang, K., Tan, S., Xin, J., Yuan, Q., Xu, H., Xu, X., Liang, Q., Christiani, D.C., Wang, M., et al. (2021). Circular RNAs in body fluids as cancer biomarkers: the new frontier of liquid biopsies. Mol Cancer 20, 13.
Wang, W., Yuan, T., Ma, L., Zhu, Y., Bao, J., Zhao, X., Zhao, Y., Zong, Y., Zhang, Y., Yang, S., et al. (2022). Hepatobiliary tumor organoids reveal HLA class I neoantigen landscape and antitumoral activity of neoantigen peptide enhanced with immune checkpoint inhibitors. Adv Sci 9, 2105810.

Wei, G., Wang, Y., Yang, G., Wang, Y., and Ju, R. (2021). Recent progress in nanomedicine for enhanced cancer chemotherapy. Theranostics 11, 6370–6392.
Welch, H.G., and Albertsen, P.C. (2009). Prostate cancer diagnosis and treatment after the introduction of prostate-specific antigen screening: 1986–2005. J Natl Cancer Insti 101, 1325–1329.
White, A.J., Gregoire, A.M., Niehoff, N.M., Bertrand, K.A., Palmer, J.R., Coogan, P.F., and Bethea, T.N. (2021). Air pollution and breast cancer risk in the Black Women's Health Study. Environ Res 194, 110651.
Willsmore, Z.N., Coumbe, B.G.T., Crescioli, S., Reci, S., Gupta, A., Harris, R.J., Chenoweth, A., Chauhan, J., Bax, H.J., McCraw, A., et al. (2021). Combined anti-PD-1 and anti-CTLA-4 checkpoint blockade: treatment of melanoma and immune mechanisms of action. Eur J Immunol 51, 544–556.
Wu, J., Zhao, X., Sun, J., Cheng, C., Yin, C., and Bai, R. (2022). The epidemic of thyroid cancer in China: current trends and future prediction. Front Oncol 12, 932729.
Wu, Y., Li, Y., and Giovannucci, E. (2021). Potential impact of time trend of lifestyle risk factors on burden of major gastrointestinal cancers in China. Gastroenterology 161, 1830–1841.e8.
Xia, C., Dong, X., Li, H., Cao, M., Sun, D., He, S., Yang, F., Yan, X., Zhang, S., Li, N., et al. (2022). Cancer statistics in China and United States, 2022: profiles, trends, and determinants. Chin Med J 135, 584–590.
Xie, J., Zhong, R., Zhu, L., Chang, X., Chen, J., Wang, W., Zhang, L., Chen, O., Yu, X., Zou, Y., and Li, Y. (2021a). Smoking cessation rate and factors affecting the success of quitting in a smoking cessation clinic using telephone follow-up. Tob Induc Dis 19, 99.
Xie, L., Wang, S., Qian, Y., Jia, S., Wang, J., Li, L., Zhang, W., Yu, H., Bao, P., and Qian, B. (2021b). Increasing gap between thyroid cancer incidence and mortality in urban Shanghai, China: an analysis spanning 43 years. Endocrine Pract 27, 1100–1107.
Xie, Y. (2017). Hepatitis B virus-associated hepatocellular carcinoma. Adv Exp Med Biol 1018, 11–21.
Xu, M., Yao, Y., Chen, H., Zhang, S., Cao, S.M., Zhang, Z., Luo, B., Liu, Z., Li, Z., Xiang, T., et al. (2019). Genome sequencing analysis identifies Epstein-Barr virus subtypes associated with high risk of nasopharyngeal carcinoma. Nat Genet 51, 1131–1136.
Xu, S., and Han, Y. (2021). The overdiagnosis of thyroid micropapillary carcinoma: the rising incidence, inert biological behavior, and countermeasures. J Oncol 2021, 5544232.
Xu, W., Zhou, G., Wang, H., Liu, Y., Chen, B., Chen, W., Lin, C., Wu, S., Gong, A., and Xu, M. (2020). Circulating lncRNA SNHG11 as a novel biomarker for early diagnosis and prognosis of colorectal cancer. Int J Cancer 146, 2901–2912.
Xu, Z., Zhang, Y., Dai, H., and Han, B. (2022). Epithelial-mesenchymal transition-mediated tumor therapeutic resistance. Molecules 27, 4750.
Xue, C., Li, G., Lu, J., and Li, L. (2021). Crosstalk between circRNAs and the PI3K/AKT signaling pathway in cancer progression. Sig Transduct Target Ther 6, 400.
Xue, Y., Wang, L., Zhang, Y., Zhao, Y., and Liu, Y. (2022). Air pollution: a culprit of lung cancer. J Hazard Mater 434, 128937.
Yang, D., Liu, Y., Bai, C., Wang, X., and Powell, C.A. (2020). Epidemiology of lung cancer and lung cancer screening programs in China and the United States. Cancer Lett 468, 82–87.
Yang, J., Wang, Z.Y., Huang, L., Yu, T.L., Wan, S.Q., Song, J., Zhang, B.L., and Hu, M. (2021). Do betel quid and areca nut chewing deteriorate prognosis of oral cancer? A systematic review, meta-analysis, and research agenda. Oral Dis 27, 1366–1375.
Yang, J., Xu, R., Wang, C., Qiu, J., Ren, B., and You, L. (2021). Early screening and diagnosis strategies of pancreatic cancer: a comprehensive review. Cancer Commun 41, 1257–1274.
Yang, J.D., and Heimbach, J.K. (2020). New advances in the diagnosis and management of hepatocellular carcinoma. BMJ 371, m3544.
Yang, J.J., Yu, D., Xiang, Y.B., Blot, W., White, E., Robien, K., Sinha, R., Park, Y., Takata, Y., Lazovich, D.A., et al. (2020). Association of dietary fiber and yogurt consumption with lung cancer risk. JAMA Oncol 6, e194107.
Yang, L., Parkin, D.M., Li, L., and Chen, Y. (2003). Time trends in cancer mortality in China: 1987–1999. Int J Cancer 106, 771–783.
Yang, Y., Han, Z., Li, X., Huang, A., Shi, J., and Gu, J. (2020). Epidemiology and risk factors of colorectal cancer in China. Chin J Cancer Res 32, 729–741.
Yang, Y., Wang, H.Y., Chen, Y.K., Chen, J.J., Song, C., and Gu, J. (2020). Current status of surgical treatment of rectal cancer in China. Chin Med J 133, 2703–2711.
Yang, Z., Zhu, Y., Xiang, G., Hua, T., Ni, J., Zhao, J., Lu, Y., Wu, Y., and Chang, F. (2021). First-line atezolizumab plus chemotherapy in advanced non-squamous non-small cell lung cancer: a cost-effectiveness analysis from China. Expert Rev Pharm Outcomes Res 21, 1061–1067.
Yin, J., Wu, X., Li, S., Li, C., and Guo, Z. (2020). Impact of environmental factors on gastric cancer: a review of the scientific evidence, human prevention and adaptation. J Environ Sci 89, 65–79.
Young, E., Philpott, H., and Singh, R. (2021). Endoscopic diagnosis and treatment of gastric dysplasia and early cancer: current evidence and what the future may hold. World J Gastroenterol 27, 5126–5151.
Yuan, S., and Xie, S.H. (2021). Urban-rural disparity in cancer incidence in China, 2008–2012: a cross-sectional analysis of data from 36 cancer registers. BMJ Open 11, e042762.
Zeng, H., Chen, W., Zheng, R., Zhang, S., Ji, J.S., Zou, X., Xia, C., Sun, K., Yang, Z., Li, H., et al. (2018). Changing cancer survival in China during 2003–2015: a pooled analysis of 17 population-based cancer registries. Lancet Glob Health 6, e555–e567.
Zhang, L., Ding, J., Li, H.Y., Wang, Z.H., and Wu, J. (2020). Immunotherapy for advanced hepatocellular carcinoma, where are we? Biochim Biophys Acta 1874, 188441.
Zhang, S., Chen, C., Xue, C., Chang, D., Xu, H., Salena, B.J., Li, Y., and Wu, Z.S. (2020). Ribbon of DNA lattice on gold nanoparticles for selective drug delivery to cancer cells. Angew Chem Int Ed 59, 14584–14592.
Zhang, Y., Ma, J.A., Zhang, H.X., Jiang, Y.N., and Luo, W.H. (2020). Cancer vaccines: targeting KRAS-driven cancers. Expert Rev Vaccines 19, 163–173.
Zhang, Y., and Zhang, Z. (2020). The history and advances in cancer immunotherapy: understanding the characteristics of tumor-infiltrating immune cells and their therapeutic implications. Cell Mol Immunol 17, 807–821.
Zhao, K., Zhou, X., Xiao, Y., Wang, Y., and Wen, L. (2022). Research progress in alpha-fetoprotein-induced immunosuppression of liver cancer. Mini Rev Med Chem 22, 2237–2243.
Zhao, L., Fu, C., Tan, L., Li, T., Zhong, H., and Meng, X. (2020). Advanced nanotechnology for hypoxia-associated antitumor therapy. Nanoscale 12, 2855–2874.
Zheng, R., Zhang, S., Zeng, H., Wang, S., Sun, K., Chen, R., Li, L., Wei, W., and He, J. (2022). Cancer incidence and mortality in China, 2016. J Natl Cancer Center 2, 1–9.
Zhou, H., and Song, T. (2021). Conversion therapy and maintenance therapy for primary hepatocellular carcinoma. Biosci Trends 15, 155–160.
Zhou, Q., Yan, X., Zhu, H., Xin, Z., Zhao, J., Shen, W., Yin, W., Guo, Y., Xu, H., Zhao, M., et al. (2021). Identification of three tumor antigens and immune subtypes for mRNA vaccine development in diffuse glioma. Theranostics 11, 9775–9790.
Zhu, L., and Lin, M. (2021). The synthesis of nano-doxorubicin and its anticancer effect. Anticancer Agents Med Chem 21, 2466–2477.
Zhu, S., Zhang, T., Zheng, L., Liu, H., Song, W., Liu, D., Li, Z., and Pan, C. (2021). Combination strategies to maximize the benefits of cancer immunotherapy. J Hematol Oncol 14, 156.
Zi, Y., Yang, K., He, J., Wu, Z., Liu, J., and Zhang, W. (2022). Strategies to enhance drug delivery to solid tumors by harnessing the EPR effects and alternative targeting mechanisms. Adv Drug Del Rev 188, 114449.