Original Article

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Abstract

Background Lung cancer ranks first in incidence and mortality nationwide, has a poor prognosis, and its disease burden increases with population aging. China still lacks a high-precision monitoring system for lung cancer risk factors. Objective To construct a high-precision early warning and monitoring standard system for lung cancer and its risk factors, further implement the strategy of early tumor detection, and achieve early and accurate identification of populations at high risk for malignant tumors. Methods From August to September 2024, literature related to lung cancer risk factors was reviewed to preliminarily construct an indicator pool for the lung cancer early warning and monitoring standard system. Two rounds of expert consultation were conducted from October 2024 to May 2025. Monitoring indicators were selected based on scores, full-score rates, and coefficients of variation, and the final lung cancer early warning and monitoring standard system was established. The reliability of the expert consultation results was evaluated by calculating the expert positivity coefficient, authority coefficient, and coordination coefficient. Results The final lung cancer early warning and monitoring standard system comprised 3 first-level indicators, 5 second-level indicators, and 20 third-level indicators. The expert positivity coefficients in the two rounds of consultation were 77.78% and 100%, respectively, and the expert authority coefficients were 0.86 and 0.93, respectively. In the second round of expert consultation, the expert coordination coefficients for validity, necessity, and availability scores were 0.243 ($P<0.001$), 0.298 ($P<0.001$), and 0.311 ($P<0.001$), respectively. Conclusion The lung cancer early warning and monitoring standard system constructed in this study was characterized by high expert enthusiasm, professional authority, and satisfactory coordination. The findings are scientific and reliable, providing a scientific basis for early warning, prevention, and control of lung cancer.

Full Text

Original Article

Study on Constructing an Early Warning and Monitoring Standard System for Lung Cancer in China Based on the Delphi Method

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Abstract Background The incidence and mortality rates of lung cancer rank first nationwide, and the prognosis is poor; the disease burden is increasing with population aging. China still lacks a high-precision monitoring system targeting risk factors for lung cancer. **Objective** To construct a high-precision early warning and monitoring standard system for lung cancer and its risk factors, further implement strategies for early tumor detection, and achieve early and accurate identification of populations at high risk for malignant tumors. **Methods** From August to September 2024, literature related to lung cancer risk factors was reviewed to preliminarily construct an indicator pool for an early warning and monitoring standard system for lung cancer. From October 2024 to May 2025, two rounds of expert consultation were conducted. Monitoring indicators were screened according to scores, full-score rates, and coefficients of variation, and the final early warning and monitoring standard system for lung cancer was established. The reliability of the expert consultation results was evaluated by calculating the expert positive coefficient, authority coefficient, coordination coefficient, and other measures. **Results** The final early warning and monitoring standard system for lung cancer included 3 first-level indicators, 5 second-level indicators, and 20 third-level indicators. The expert positive coefficients in the two rounds of consultation were 77.78% and 100%, respectively, and the expert authority coefficients were 0.86 and 0.93, respectively. In the second round of expert consultation, the expert coordination coefficients for validity scores, necessity scores, and availability scores were 0.243 ($P < 0.001$), 0.298 ($P < 0.001$), and 0.311 ($P < 0.001$), respectively. **Conclusion** The early warning and monitoring standard system for lung cancer constructed in this study showed high expert enthusiasm, professional authority, and an ideal degree of coordination. The findings are scientific and reliable and provide a scientific basis for early warning, prevention, and control of lung cancer.

[**Keywords**] Lung cancer; Delphi method; monitoring indicator system

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Abstract Background The incidence and mortality rates of lung cancer rank first nationwide, with poor prognosis, and the disease burden is increasing with an aging population. China still lacks a high-precision monitoring system for lung cancer risk factors. **Objective** To establish a high-precision early warning monitoring standard system for lung cancer and its risk factors, further implement strategies for early tumor detection, and achieve early and accurate identification of high-risk populations for malignant tumors. **Methods** From August to September 2024, a preliminary pool of indicators for the early warning monitoring standard system of lung cancer was constructed by reviewing literature related to lung cancer risk factors. From October 2024 to May 2025, two rounds of expert consultations were conducted. Monitoring indicators were selected based on scores, full score rates, and coefficient of variation to establish the final early warning monitoring standard system for lung cancer. The expert consultation results are evaluated through the positive coefficients of experts, coefficient of authority, the Kendall' s harmony coefficients, etc. **Results** The final evaluation index system included 3 first-level indicators, 5 second-level indicators, and 20 third-level indicators. The positive coefficients of the experts in the two rounds of consultation were 77.78% and 100% respectively. The expert authority coefficients in the two rounds of consultation were 0.86 and 0.93 respectively. The Kendall' s harmony coefficients for the validity score, necessity score and availability score in the second round of expert consultation were 0.243 ($P < 0.001$), 0.298

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($P < 0.001$) and 0.311 ($P < 0.001$), respectively. **Conclusion** The standard system for early warning and monitoring of lung cancer constructed in this study features high expert enthusiasm, good authority and coordination. The research results are scientific and reliable, providing a scientific basis for the early warning and prevention and control of lung cancer.

【**Key words** 】Lung cancer; Delphi method; Monitoring index system

Lung cancer is one of the most common cancers worldwide. In 2022, both its incidence and mortality ranked first in the world[1]. Lung cancer is also the most common malignant tumor in China and the leading cause of cancer death[2]. In Pudong New Area, Shanghai, lung cancer is one of the principal causes of death[3]. The occurrence of lung cancer is influenced by the combined effects of multiple factors, including the environment, genetics, and lifestyle. Smoking is the major risk factor for lung cancer, while family history, diet, air pollution, occupational exposure, and other factors are also closely associated with its occurrence[4]. Early detection, early diagnosis, and early treatment of cancer can reduce patients' disease and economic burden and increase the possibility of cancer cure[5]. The WHO has pointed out that approximately 30%–50% of malignant tumors[5] can be prevented by controlling risk factors and implementing effective preventive measures. Therefore, systematic monitoring of cancer-related risk factors and early identification of populations at high risk of cancer are of vital importance for cancer prevention and control.

China' s current tumor surveillance mainly relies on passive surveillance based on case reporting, and there is still a lack of a direct and systematic surveillance system targeting risk factors for malignant tumors[6]. On the basis of a comprehensive review of relevant literature, this study used the Delphi method to extensively collect and integrate opinions and suggestions from experts in related fields, with the aim of constructing a high-precision early-warning and monitoring standard system for lung cancer and its risk factors, further implementing the strategy of early tumor detection, accurately identifying high-risk populations for malignant tumors at an early stage, and reducing the cancer burden.

1 Materials and Methods

1.1 Construction of the Indicator-System Framework

From August to September 2024, with reference to the cancer surveillance and reporting system currently used in Shanghai, as well as diagnosis and treatment items for oncology patients in secondary and tertiary hospitals in Shanghai, relevant domestic and international literature was searched in professional databases such as CNKI, Wanfang Data Knowledge Service Platform, and PubMed using keywords including "lung cancer," "risk factors," and "incidence" [6–11]. Various risk factors potentially related to lung cancer incidence were reviewed and summarized. In combination with the actual situation of malignant-tumor surveillance in Shanghai, the research team, after group discussion, preliminarily formulated an item pool of indicators for a high-precision monitoring standard system for lung cancer. A preliminary early-warning and monitoring standard system for lung cancer was constructed, comprising 4 first-level indicators, 17 second-level indicators, and 73 third-level indicators. The first-level indicators were basic personal information, risk-factor information, clinical diagnosis and treatment information, and individual case information. The second-level indicators were personal status, family status, smoking, dietary habits, infection and chronic inflammatory disease status, environmental factors, ionizing radiation, occupational exposure, social environmental factors, accessibility of medical conditions, diagnosis and treatment status, medication status, pathological examination, imaging and ultrasound examinations, information on lung cancer patients, patient follow-up status, and patient death information.

1.2 Methods

From October 2024 to May 2025, the Delphi method was applied to conduct two rounds of expert consultation on the preliminarily drafted early-warning and monitoring standard system for lung cancer. The expert consultation results were statistically analyzed, expert opinions were summarized, the indicators of the monitoring system were adjusted, and the final early-warning and monitoring standard system for lung cancer in China was determined through group discussion. This study strictly followed the principles of broad coverage, authority, and representativeness. Experienced professionals from centers for disease control and prevention, institutions of higher education and research institutes, and oncology specialty hospitals—mainly engaged in fields related to tumor prevention, control and monitoring, and clinical treatment of lung malignancies—were invited to form the expert consultation panel and participate in this study.

1.2.1 Preparation of the Expert Consultation Questionnaire The expert consultation questionnaire consisted of four parts: an explanation of the research background, instructions for completion, an indicator evaluation form, and basic expert information. The indicator evaluation form was divided into indicator scoring and evaluation of expert authority. For indicator scoring, experts quantitatively scored the effectiveness, necessity, and availability of each indicator using integer scores from "1–10 points" ; a higher score indicated a more prominent corresponding attribute. Evaluation of expert authority mainly included the experts' familiarity with the indicators (C_s), the basis for their scoring judgments (C_a), and the degree of influence. Experts' familiarity with the indicators was divided into five levels: "familiar, relatively familiar, average, relatively unfamiliar, and unfamiliar" ; the quantitative values for familiarity were 1.0, 0.8, 0.6, 0.4, and 0.2, respectively[12–13].

1.2.2 Conducting the Consultation In this study, invitation letters and expert consultation questionnaires for two rounds of consultation were sent to experts by e-mail. Each round of consultation lasted 2 weeks. After the first round of consultation, the feedback from experts was promptly subjected to statistical analysis, and indicator screening and revision were completed. When the second round of consultation was conducted, the statistical analysis results of the first round, the indicator revisions, and a summary of relevant opinions were provided to the experts as reference materials for their second-round scoring. During each round of expert consultation, experts were not allowed to discuss with one another. The questionnaire was revised based on the expert consultation results, expert opinions, and group discussion until the experts reached consensus on the research questions[14].

1.2.3 Criteria for Indicator Screening The statistical analysis included calculation of the mean score, full-score frequency, and coefficient of variation for each indicator. Third-level indicators for which the mean score in any one dimension—effectiveness, necessity, or availability—was less than or equal to the mean score of all indicators in that dimension, with a coefficient of variation >0.25 and a full-score rate <50%, were deleted[15]. For other indicators, according to the needs of the research topic and expert opinions, the research team reached consensus after discussion and jointly decided on indicator modification, addition, and deletion.

1.3 Statistical Analysis

Excel 2019 and SPSS 26.0 software were used for data collation and statistical analysis. Count data were expressed as composition ratios. By analyzing expert enthusiasm, expert authority, and the degree of coordination of expert opinions, the expert consultation

The reliability of the results was evaluated. Expert positivity was measured by the effective questionnaire recovery rate, i.e., the percentage of valid questionnaires returned among all questionnaires distributed; this indicator reflects the degree of experts' attention to and cooperation with the study. The expert authority coefficient (Cr) was jointly represented by experts' familiarity with the consultation questions (Cs) and the judgment basis (Ca), calculated as $Cr = (Ca + Cs)/2$, with values ranging from 0 to 1[^16-18]. Among these, the assignment of Ca was based on the quantified value of the degree of influence of the judgment basis (Table 1). The higher the Cr value, the higher the degree of expert authority. The degree of coordination of expert opinions was evaluated using the expert coordination coefficient (Kendall' s W coefficient). The value of W ranges from 0 to 1; if the W value is larger and statistically significant[^19-20], it indicates that experts' evaluations of the indicators have good consistency and that the consultation results are relatively reliable. The significance level was $\alpha = 0.05$.

Table 1 Scoring criteria of judgment basis and influence degree

Judgment basis	Influence degree on expert judgment: High	Influence degree on expert judgment: Medium	Influence degree on expert judgment: Low
Theoretical analysis	0.3	0.2	0.1
Practical experience	0.5	0.4	0.3

Judgment basis	Influence degree on expert judgment: High	Influence degree on expert judgment: Medium	Influence degree on expert judgment: Low
Reference to domestic and foreign materials	0.1	0.1	0.1
Intuition	0.1	0.1	0.1

2 Results

2.1 Basic information of experts

A total of 14 experts were invited to participate in the two rounds of consultation, including 11 men (78.57%) and 3 women (21.43%). The mean age was (45.0 ± 9.0) years, with most experts aged 41-50 years, accounting for 42.86%. There were 2 experts with a bachelor' s degree (14.29%), 3 with a master' s degree (21.43%), and 9 with a doctoral degree (64.29%). Twelve experts had senior professional titles (85.71%). In terms of years engaged in tumor prevention and control, 3 experts had worked for 10 years or less (21.43%), 6 for 11-20 years (42.86%), 2 for 21-30 years (14.29%), and 3 for more than 30 years (21.43%). Two experts came from disease prevention and control centers (14.29%), 3 from universities and research institutions (21.43%), and 9 from cancer hospitals (64.29%).

2.2 Expert positivity coefficient

In the first round of expert consultation, questionnaires were distributed to 18 experts, and 14 questionnaires were returned, with an effective questionnaire recovery rate of 77.78%. In the second round of expert consultation, 14 questionnaires were distributed, and 14 were returned, with an effective questionnaire recovery rate of 100.00%. The proportions of experts who provided comments in the two rounds of expert consultation were 57.14% and 35.71%, respectively.

2.3 Authority of expert opinions

Based on experts' familiarity with the questions and their evaluation of the judgment basis and degree of influence in the two rounds of questionnaires, the expert authority coefficients were calculated. The $Cr1$ for the first round of consultation was 0.86, and the $Cr2$ for the second round of consultation was 0.93.

2.4 Coordination of expert opinions

To evaluate the consistency of experts' scores for the validity, necessity, and availability of each indicator in the two rounds of expert consultation, the expert opinion coordination coefficients were calculated and significance tests were performed. In the first round of expert consultation, the expert coordination coefficients for the validity score, necessity score, and availability score of the overall monitoring indicator system were 0.347, 0.448, and 0.365, respectively ($P < 0.001$). Among first-level indicators, the coordination of experts' validity scores, necessity scores, and availability scores for the "case personal information" category was not statistically significant ($P > 0.05$) (Table 2).

In the second round of expert consultation, the expert coordination coefficients for the validity score, necessity score, and availability score of the overall monitoring indicator system were 0.243, 0.298, and 0.311, respectively ($P < 0.001$). The number of indicators in the first-level indicator category "clinical diagnosis and treatment information" was fewer than 3, so the expert coordination coefficient could not be calculated (Table 3). The third-level indicators under this first-level indicator were "pathological examination time, anatomical site, pathological diagnosis, etc." and "lung-related imaging examination type (X-ray/CT/MRI), examination time, examination result." The mean scores for the three dimensions of these two third-level indicators were all >8 points; the pass rates for validity and necessity were both >50%, and the coefficients of variation were both <0.25. Differences in expert opinions mainly existed in the availability of these two third-level indicators. The availability pass rate of the third-level indicator "pathological examination time, anatomical site, pathological diagnosis, etc." was 42.86%, with a coefficient of variation of 0.24; the availability pass rate of "lung-related imaging examination type (X-ray/CT/MRI), examination time, examination result" was 35.71%, with a coefficient of variation of 0.29.

2.5 Indicator screening

2.5.1 Results of the first round of expert consultation In the first round of expert consultation, the validity scores of the indicators ranged from 4.21 to 9.14, the coefficients of variation ranged from 0.10 to 0.75, and the pass rates ranged from 0 to 64.29%; the necessity scores ranged from 3.86 to 9.43,

Table 2 Kendall's coefficients of concordance of expert opinions for the validity, necessity, and availability scores of the first-level indicators in the first round of the Delphi method

First-level indicator	Number of indicators	Validity: Kendall' s W coefficient	Validity: χ^2 value	Validity: P value	Necessity: Kendall' s W coefficient	Necessity: χ^2 value	Necessity: P value	Availability: Kendall' s W coefficient	Availability: χ^2 value	Availability: P value
Personal basic information	21	0.374	104.610	<0.001	0.522	146.260	<0.001	0.403	112.913	<0.001
Risk factor information	39	0.345	183.314	<0.001	0.429	228.097	<0.001	0.293	155.850	<0.001
Clinical diagnosis and treatment information	10	0.352	44.385	<0.001	0.407	51.291	<0.001	0.199	25.039	0.003
Case personal information	3	0.179	5.000	0.082	0.167	4.667	0.097	0.132	3.700	0.157
Total	73	0.347	349.416	<0.001	0.448	451.129	<0.001	0.365	367.772	<0.001

Table 3 Kendall' s coefficients of concordance for expert opinions on the effectiveness, necessity, and availability of first-level indicators in the second round of the Delphi method

First-level indicator	Number of indicators	Effectiveness: Kendall's W coefficient	Effectiveness: χ^2 value	Effectiveness: P value	Necessity: Kendall's W coefficient	Necessity: χ^2 value	Necessity: P value	Availability: Kendall's W coefficient	Availability: χ^2 value	Availability: P value
Personal basic information	11	0.251	35.165	<0.001	0.344	48.157	<0.001	0.345	48.353	<0.001
Risk factor information	15	0.287	56.158	<0.001	0.312	61.105	<0.001	0.349	68.405	<0.001
Clinical diagnosis and treatment information	2	/	/	/	/	/	/	/	/	/
Total	28	0.243	91.831	<0.001	0.298	112.750	<0.001	0.311	117.389	<0.001

Note: / indicates that data for this item could not be obtained.

The coefficient of variation ranged from 0.08 to 0.77, and the full-score rate ranged from 0 to 71.43%; the availability score ranged from 4.86 to 9.86, the coefficient of variation ranged from 0.08 to 0.73, and the full-score rate ranged from 7.14% to 85.71%. According to the indicator screening criteria, a total of 7 secondary indicators and 43 tertiary indicators were considered for deletion or revision. Based on the study objectives and experts' open-ended comments, and according to three operational criteria—relevance of the indicators to this study, data accessibility, and practical operability—the research group reached consensus through discussion and jointly decided to delete 1 first-level indicator, namely case personal information; 3 secondary indicators, including lung cancer patient information, patient follow-up status, and patient death information; and 5 tertiary indicators, including whether the patient was exposed to toxic and hazardous substances at work; previous pulmonary diseases; tumor diagnosis hospital, diagnosis date, diagnosis name, site, pathological type, and TNM stage; treatment/medication status; recurrence/metastasis date and location, changes in disease condition, etc.; and time of death, place of death, and cause of death. Among them, 2 tertiary indicators– "whether the patient was exposed to toxic and hazardous substances at work" and "previous pulmonary diseases" –were considered for deletion because they overlapped with the secondary indicators "occupational exposure"and "infectious and chronic inflammatory disease status" under the first-level indicator "risk factors."The wording of 12 tertiary indicators was revised, forming a monitoring indicator system for use in the second round of expert consultation, including 3 first-level indicators, 7 secondary indicators, and 28 tertiary indicators.

2.5.2 Results of the second round of expert consultation

In the second round of expert consultation, the effectiveness scores for the indicators ranged from 7.64 to 9.93, the coefficient of variation ranged from 0.03 to 0.31, and the full-score rate ranged from 28.57% to 92.86%; the necessity scores ranged from 7.64 to 10.00, the coefficient of variation ranged from 0 to 0.41, and the full-score rate ranged from 28.57% to 100.00%; the availability scores ranged from 7.00 to 9.93, the coefficient of variation ranged from 0.03 to 0.40, and the full-score rate ranged from 7.14% to 100.00%. According to the indicator screening criteria, 2 secondary indicators were considered for deletion, including infectious and chronic inflammatory disease status and imaging examination; and 8 tertiary indicators, including whether family members or colleagues smoke and age at smoking initiation; partner' s smoking frequency and average amount smoked; family members' or colleagues' smoking frequency and average amount smoked; whether the patient has chronic obstructive pulmonary disease, disease duration, and medication status; whether the patient has asthma, disease duration, and medication status; whether the patient has pulmonary tuberculosis, disease duration, and medication status; whether the patient has chronic inflammation of the lung parenchyma, disease duration, and medication status; and type of lung-related imaging examination (X-ray/CT/MRI), examination time, and examination results.

Compared with the results of the first round of expert consultation, the coefficient of variation in the second round decreased, the full-score rate increased, and all scores were $ $7 points. The experts' opinions tended to be consistent, and the correspondence consultation was terminated. Based on the expert consultation results and opinions, and after group discussion, the standard index system for high-precision early warning and monitoring of lung cancer in China, initially constructed in this study, was finalized as shown in Table 4. It contains 3 first-level indicators, 5 secondary indicators, and 20 tertiary indicators.

Table 4 Standard index system for high-precision early warning and monitoring of lung cancer in China

First-level indicator	Second-level indicator	Third-level indicator
Personal basic information	Personal status	ID number
Personal basic information	Personal status	Sex
Personal basic information	Personal status	Occupation (before retirement)
Personal basic information	Personal status	Educational level
Personal basic information	Personal status	Height
Personal basic information	Personal status	Body mass
Personal basic information	Personal status	History of lung cancer, disease duration, pathological type, etc.
Personal basic information	Personal status	Whether the individual undergoes regular physical examinations
Personal basic information	Personal status	Whether the individual has actively learned about lung cancer-related knowledge
Personal basic information	Family status	Family history of lung cancer
Personal basic information	Family status	Family history of pulmonary disease
Risk factor information	Smoking	Whether the individual smokes, age at smoking initiation
Risk factor information	Smoking	Smoking frequency, average amount smoked
Risk factor information	Smoking	Type of smoking product (cigarettes, electronic cigarettes, pipe tobacco, cigars, etc.)

First-level indicator	Second-level indicator	Third-level indicator
Risk factor information	Smoking	Whether the individual has quit smoking, whether relapse occurred after quitting, age at relapse
Risk factor information	Smoking	Whether the partner smokes, age at smoking initiation
Risk factor information	Occupational exposure	Whether the individual is engaged in an occupation related to ionizing radiation
Risk factor information	Occupational exposure	Whether the individual is engaged in an occupation related to asbestos, silicon dioxide, heavy metals, polycyclic aromatic hydrocarbons, or radon
Risk factor information	Occupational exposure	Whether the individual works underground in mines and is exposed to radioactive radon
Clinical diagnosis and treatment information	Pathological examination	Time of pathological examination, tissue site, pathological diagnosis, etc.

3 Discussion

3.1 Necessity and value of constructing a standard system for early warning and monitoring of lung cancer

Lung cancer is the leading cause of cancer death worldwide, with more than 1.8 million people dying from lung cancer each year[^21]. Globally, the five-year net survival rate for lung cancer is 10%-20%, making it the cancer with the lowest survival rate[^22]. Lung cancer severely

endangers human health and imposes a heavy medical and economic burden on society. Building on traditional passive surveillance, this study used the Delphi method to construct a standard system for early-warning surveillance of lung cancer, thereby overcoming the limitations of most existing early-warning surveillance standard systems, which have been developed mainly for infectious diseases. This study attempted to reduce the incidence of lung cancer among high-risk populations through early warning, and to improve lung cancer survival through early detection and early treatment, providing a reference for the future establishment of an effective early-warning surveillance system for malignant tumors in China.

3.2 Evaluation of the Standard System for Early-Warning Surveillance of Lung Cancer Constructed by the Delphi Method

The Delphi method has been widely recognized in fields related to the construction and evaluation of indicator systems[23–25]. Selecting a representative expert panel is essential to ensuring the scientific rigor and validity of a study[26]. The Delphi method has high requirements for experts' authority and cooperation. While ensuring expert authority, in order to improve expert compliance, the research team invited a relatively large number of experts from Beijing and Shanghai. Ultimately, the experts who provided valid responses were concentrated in the Beijing–Shanghai region, where compliance was relatively good, mainly reflecting cancer surveillance conditions in economically developed regions. All experts were authoritative specialists engaged in tumor prevention and control, public health, and related fields; they were familiar with the content of this study and had a certain degree of recognition and representativeness in the field of lung cancer prevention and treatment.

The valid response rates for the two rounds of expert consultation were 77.78% and 100%, respectively, and the proportions of experts who provided guiding comments were 57.14% and 35.71%, respectively. Expert enthusiasm was high; the experts were interested in and supportive of the study content, indicating that this study has certain research value[26]. The expert authority coefficients in both rounds of consultation were higher than 0.7, indicating that the experts had relatively high authority in this research field and that the credibility of the results was high[27]. Compared with the Kendall's W coefficient from the first round of expert consultation, the Kendall's W coefficient from the second round decreased markedly. This may be because experts from different industries had essentially different core concerns regarding the surveillance system, leading to greater divergence in some local opinions and a decline in Kendall's W. After the first round of screening, the indicators in the second round were described more specifically, increasing experts' sensitivity to details; this may also have contributed to the decrease in Kendall' s W. The reduction in the number of indicators may also have been one of the statistical reasons for the decline in Kendall' s W

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In the Kendall' s W coefficient test of the first round of expert consultation, experts differed substantially in their opinions on whether to include or exclude the first-level indicator "individual case information." Some experts believed that the high-precision lung cancer surveillance standard system constructed in this study was prevention-oriented, and that clinical management information for already diagnosed patients was not a risk factor for lung cancer occurrence and should not be included in the surveillance system. Other experts suggested that the third-level indicators under this first-level indicator were too complex, difficult to collect, and of no practical value. To ensure consistency with the objectives of the indicator system and practical operability, it was ultimately decided to delete this first-level indicator and all of its subordinate second- and third-level indicators.

In the second round of expert consultation, differences of opinion among experts from different specialties were mainly concentrated on the evaluation of the necessity of "basic personal information" and the validity and necessity of "clinical diagnosis and treatment information." This may be because clinical specialists and public health specialists have essentially different core concerns regarding surveillance indicators. To ensure that the high-precision lung cancer surveillance indicator system constructed in this study would be operable at the stage of initial clinical reporting, this study invited more experts engaged in clinical tumor prevention and treatment to participate in the consultation. Experts from different industries placed different emphases on the clinical practicality and public health surveillance attributes of the indicator system. Clinical experts emphasized data collection and interpretation of clinical significance, whereas public health experts emphasized integrated data analysis and the realization of surveillance functions. In the preliminary exploratory stage of indicator screening, prioritizing the clinical accessibility of indicators helps the subsequent implementation of the surveillance system. Although the number of public health specialists in this study was relatively small, they still played a key role in safeguarding surveillance attributes and conducting standardized evaluation during the indicator screening process, and played an important role in controlling the direction of the lung cancer surveillance indicator system. On the premise of ensuring clinical accessibility, surveillance needs were also taken into account; however, further studies should increase the proportion of public health specialists as needed, so as to optimize the balance of the indicator system in terms of population surveillance attributes.

This study was conducted strictly in accordance with the expert consultation procedures of the Delphi method, and the statistical analysis was rigorous and reliable. Ultimately, a standard system for early-warning surveillance of lung cancer was screened out, comprising 3 first-level indicators, 5 second-level indicators, and 20 third-level indicators. The core surveillance indicators of existing tumor registration and reporting systems and lung cancer screening programs are mainly concentrated on basic demographic information, registration of lung cancer incidence and death, pathological diagnosis information, and related content, with emphasis on registration and follow-up of lung cancer patients. The lung cancer surveillance system constructed in this study added indicators such as smoking status, occupational exposure, and health behaviors, shifting the surveillance threshold forward to the stage of risk identification and early warning among high-risk populations, and providing data support for primary and secondary prevention of lung cancer. At the same time, the surveillance system constructed in this study incorporated multiple risk factors, achieving a transition from single-factor surveillance to multifactor comprehensive assessment. Dynamic monitoring of smoking status among high-risk populations can accurately assess changes in individual risk and provide individualized intervention measures in a timely manner, thereby offering a reference for early-warning prevention and control of lung cancer.

3.3 Limitations of the Standard System for Early-Warning Surveillance of Lung Cancer

This surveillance standard system still has some shortcomings. The indicators cover a broad range, and in practical application there may be specific problems such as difficulty in collecting indicators and the need to further simplify or refine third-level indicators; further research and exploration are still required. The Delphi expert consultation method commonly involves selection bias [29–30]. The experts invited in this study all came from the Beijing-Shanghai region; therefore, the preliminarily constructed lung cancer surveillance system is more applicable to economically developed urban areas and has insufficient regional representativeness. To ensure data accessibility, more experts from cancer hospitals were invited to participate in the study. The lung cancer surveillance system constructed in this study is more applicable to the clinical reporting stage, and its surveillance attributes are relatively weak.

This study is in the exploratory stage of indicator system construction, and the classic Delphi method was selected for indicator screening and optimization. The analytic hierarchy process can be used for refined calculation of indicator weights, and principal component analysis can be used for decomposition of subjective weights [31]. In the preliminary exploratory stage of surveillance system construction, the primary goal is to screen indicators and reach expert consensus, rather than to precisely calculate complex hierarchical weights among indicators. In addition, the expert sample size invited in this study was small and the number of indicators was large; using the analytic hierarchy process for pairwise comparisons would increase the burden on experts and reduce the response rate

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, while principal component analysis has high requirements for the number of experts. Therefore, the above methods were not adopted in this study. In future lung cancer surveillance

In subsequent research on optimizing the indicator system, the analytic hierarchy process and principal component analysis can be further combined to refine the calculation of weights.

Author contributions: Wei Zhimin was responsible for proposing the construction of a standard system for early-warning monitoring indicators for lung cancer through the Delphi expert consultation method, designing the expert consultation questionnaire, collecting, organizing, and analyzing the data, and drafting the manuscript; He Xin was responsible for designing the expert consultation questionnaire and collecting and organizing the data; Duan Yuxin, Ying Jiali, and Chen Hanyi were responsible for designing the expert consultation questionnaire; Hao Lipeng was responsible for revising the final version; Zhang Li was responsible for proposing the construction of a standard system for early-warning monitoring indicators for lung cancer through the Delphi expert consultation method, designing the expert consultation questionnaire, revising the final version, and taking responsibility for the paper.

This article has no conflicts of interest.

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