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The dynamic evolution mechanism of public health risk perception and the choice of policy tools in the post-epidemic era: Evidence from China

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ABSTRACT

Objectives: Repeated outbreaks of small-intensity epidemics are one of the important features of the post-epidemic era. After a new round of epidemics broke out in Liaoning in mid-May 2021, the Chinese government’s vaccination process quickly accelerated, completing nearly 100 million doses of COVID-19 vaccination within 7 days. How is this efficient policy implementation process accomplished? What is the behavioral logic behind it?

Methods: This article constructs an analysis framework of “perception-goal-tool”. Trying to study the individual’s micro-psychological mechanism as a starting point, with the help of a Health Belief Model, to explore the dynamic evolution of individual health risk perception before and after the outbreak of a small-intensity epidemic and its impact on vaccination willingness. And on this basis, analyze the flexible governance process of the Chinese government in the post-epidemic period.

Results: The perceived severity is the core variable that affects the public’s willingness to vaccinate. A small-intensity epidemic outbreak will aggravate the impact of the three health belief components on the public’s willingness to vaccinate. In the three interactive analyses of health belief components, individuals have the highest willingness to inoculate in situations of low perceived susceptibility, low perception barriers, and high perception severity, and economic policy tools and authoritative policy tools play a key role before and after the outbreak of a small-intensity epidemic.

Conclusion: In the context of a small-intensity epidemic, the reason why the Chinese government can achieve rapid crisis management lies in the interaction between policy goals, policy tools, and public risk perception.

1. Introduction

Modern risks are characterized by uncertainty, linkage, reflexivity, class, and globality [1]. The 2020 COVID-19 pandemic has already had a huge impact on global economic and social development [2]. As a risk of globalization, the COVID-19 epidemic inevitably affects everyone in the world [3]. According to the real-time big data report of Baidu’s COVID-19 epidemic, as of May 30, 2021, nearly 170 million people worldwide have been diagnosed with the COVID-19 virus. On average, about one in 41 people has been infected, and its spread and influence can be seen [4]. Judging from the epidemic coefficient of the new coronavirus, if humans...
want to achieve the effect of herd immunity, about 75%–85% of the population must form antibodies against the new coronavirus [5]. Therefore, in the post-epidemic era, vaccination has become a new proposition for the government’s public health risk management [6].

According to the currently known information, the COVID-19 pandemic is a major public health crisis with great harm, wide spread, and long duration [7]. Although the peak period of the epidemic has passed, in the post-epidemic era, repeated small-intensity epidemics and the continuous mutation of the virus are still a realistic situation that the public cannot escape [8]. On May 14, 2021, a new round of local epidemics broke out in Liaoning, China, which once again stirred the nerves of the public. On May 23, a new local case was discovered in Guangzhou, China, which aroused widespread public concern. Such small-intensity outbreaks have had an important impact on public perception and sentiment [9] and have posed new challenges to the choice of government policy tools [10]. Before the outbreak of small-scale outbreaks, vaccine hesitancy was a difficult problem faced by the government in epidemic prevention and control [11]. During this period, China’s vaccination process was very slow. But after a small outbreak, many people lined up overnight to get vaccinated at community hospitals [12], and the government’s main task has shifted to adopting a powerful combination of policy tools to quickly resolve the crisis while minimizing the impact of the epidemic on economic production [13]. From May 16 to May 23, 2021, Chinese health authorities have administered nearly 100 million doses of the new crown vaccine in just seven days [14]. This efficient policy process is in stark contrast to that before the outbreak of the small-scale epidemic, and this study attempts to analyze and summarize the internal logic behind this transition, which has important implications for public health risk governance in the post-epidemic period.

The main purpose of this paper is to explore the potential mechanism between the dynamic changes of public health risk perception and the combination of government policy tools. Analysis situation. Specifically, the purpose of this study is: (1) To analyze the dynamic evolution mechanism of public health risk perception before and after small-intensity outbreaks. (2) Evaluate a range of policy tools used by the Chinese government before and after small outbreaks. (3) Find the underlying mechanism between changes in public health risk perception and the Chinese government’s choice of policy tools.

In the past risk management research, scholars have mostly used the causal chain model as a representative to explore the specific impact of public risk attitudes, beliefs, and norms on behavior patterns in a single situation [15–17]. However, the individual’s health risk perception is not static in public crisis events, but changes continuously with the evolution stage of risk [18,19]. Individual health risk perception and health behavior may show different characteristics in different crisis stages [20]. In the post-epidemic period, small-intensity epidemics repeatedly impacted the public’s original health belief system, which exacerbated the change in public health risk perception [21]. However, existing research has rarely paid attention to this issue.

This study not only focuses on the transformation of public health risk perception before and after small-scale outbreaks. At the same time, we use a classic model in the field of health risk—the Health Belief Model (HBM) [22], to analyze the impact of the interaction between different health belief components on public health behavior. For example, whether there is an interaction between the risk perception of vaccine efficacy and safety and the risk perception of infection with the new coronavirus. And how does this affect the public’s willingness to behave in a healthy way? How should the government respond? In the recovery stage of public crisis management, the main purpose of the government is to restore the normal production and living order of the society, and economic policy tools based on market players are widely used [23]. However, in the face of major public health events, the recovery chain of the crisis has been significantly prolonged, and the small-intensity outbreaks have continued to recur, causing the government’s short-term policy goals to shift [24]. This requires the government’s response methods to be more flexible [25], through flexible policy combinations, adjust the deviation of individual health behavior willingness and policy goals before and after the outbreak of small-intensity epidemics [26], so as to achieve rapid and effective governance of public crises. Therefore, this paper constructs a “perception-goal-tool” analysis framework, collects data on the public’s perception changes before and after the outbreak of small-intensity outbreaks and a series of policy tools adopted by the Chinese government, and attempts to analyze the potential mechanism of action between the two, thus providing a new practical tool for public crisis management in the post-epidemic period.

The rest of the structure of this paper is arranged: the second part will elaborate the connotation of the “perception-goal-tool” analytical framework; the third part will explain the data collection process, the selection of variables and the methods used in this study; the fourth part will provide empirical analysis The fifth section will further discuss the potential mechanisms of public health risk perception and the choice of government policy tools; the sixth section summarizes the findings of this paper and the limitations of the study, and proposes an outlook for future research.

2. The “perception-goal-tool” analysis framework

The public is the core subject in public health incidents. It is not only a participant in the entire public incident, but also an important main force in policy formulation and implementation [27]. Existing studies mostly take the individual’s psychological mechanism as the starting point. From the perspective of social psychology, the public’s risk perception and behavioral mechanisms have been discussed in depth [28–30]. Therefore, some classic risk perception models and psychometric paradigms have been widely used.

However, this research paradigm has also been criticized by public management scholars or practitioners because it seems to be a derivative of psychological experiments and lacks dialogue with public management and public policy practices [31]. Taking the health belief model as an example, it mainly emphasizes the individual’s characteristics of risk, and the overall perception of information reception and transmission, which constitute the behavioral basis for individuals to take countermeasures and are also the internal key motivation [22]. But from the perspective of government public crisis governance, the attitude and emotional guidance of the public facing crisis is not only the work content of government crisis governance, but also the role of risk communication [32].
Therefore, the public’s risk perception and health behavior are bound to be affected by the government’s policy goals and policy tools. Guo Yue [31] and others constructed a public policy analysis framework of “tool-narrative-feedback”, trying to transcend individual static behavior mechanism research, and emphasize the dynamic narrative process of social situations. Among them, the policy instrument dimension mainly discusses the static mechanism of public policies affecting micro-individuals; the narrative dimension focuses on the function of social situations, emphasizing the dynamic impact of policy processes on micro-individuals; feedback dimension past policies act on micro-individuals and influence future changes. Following this logic, this article uses the health belief model as the basis to demonstrate the static behavior mechanism of individuals. Based on the dynamic changes in the perception of health belief components after the outbreak of a small-intensity epidemic, this paper discusses the changes in individual behavioral willingness and the dynamic process of government crisis response. Finally, an explanatory framework of “perception-goal-tool” is built, as shown in Fig. 1.

**Health belief perception:** From the perspective of the policy system, the public’s risk perception is the bridge between the policy subject and the policy object. It is not only the basis of an external behavior mechanism, but also the role of government policy tools [33]. This paper uses the health belief model to analyze the behavior mechanism of individuals in the context of crisis. The Health Belief Model (HBM) is one of the most classic theories for understanding health and disease behavior [34]. The HBM mainly includes four components: perceived severity, perceived susceptibility, perceived benefits and Perceived barriers.

In previous studies, the impact of a single health belief component perception on public health behavior has been verified by many scholars [35–37]. However, there are few studies on the influence of the interaction mechanism between various health belief components on individual behavior in different crisis situations. Obviously, the perceived strength of different health belief components in real situations may trigger different behavioral results. For example, after the outbreak of a small-intensity epidemic, some Chinese people’s willingness to vaccinate the COVID-19 vaccine has increased significantly, while some people’s willingness to vaccinate has declined due to problems such as difficult appointments and vaccinations [38]. Behind the results of these two behaviors are the differences in individual risk perception severity and risk perception barriers. Therefore, the interactive analysis of individual health belief components can fully explore the micro-behavior mechanism and provide a foothold for the government’s strategic choices.

**Policy goal:** Policy goal refers to the objectives and indicators to be achieved by government actions [39]. The policy goal is the prerequisite for the choice of policy tools, and it is also a reflection of the people’s appeals and feedback. Looking back on the series of measures taken by the Chinese government throughout the post-epidemic phase, the government’s Policy goals are mainly reflected in the two characteristics of economic recovery and crisis management. From the perspective of actual governance, risk managers often divide crisis governance into four stages: mitigation stage, preparation stage, response stage, and recovery stage [23]. Depending on the different stages of crisis evolution, the goals of government crisis governance also have their own focus. However, in the post-epidemic period, small-intensity epidemics have repeatedly promoted the government’s short-term strategic goals to be more flexible. This promotes the interaction between the government’s policy goals, the public’s risk perception, and the government’s policy tools to form precise, efficient and rapid adjustments.

**Policy tool:** Policy tools refer to the government’s transformation of its policy goals into a series of actions and mechanisms [40]. According to Salamon, the action structure stipulated by policy tools is an institutionalized and structured action model whose purpose is to solve public problems [41]. Therefore, from the ontological point of view, policy tools are not only compatible with policy goals, but also affect the public.

In terms of the classification of policy tools, many studies have adopted Howlett and Ramesh’s views [42], dividing policy tools into authoritative policy tools, voluntary policy tools, economic policy tools, and information policy tools. The basis for this division emphasizes the functional attributes of the policy tools themselves; Other scholars, represented by Rothwell [43], classify policy tools into three categories: supply-oriented, environment-oriented, and demand-oriented. This division attempts to weaken the compulsory characteristics of the policy tools themselves, and focus on the specific areas where the policy functions, thereby enhancing the target pertinence and content orientation of the policy tools. This research is based on the specific research situation of policy strategy.

![Fig. 1. The “Perception-goal-Tool” analysis framework.](image-url)
selection under a small-intensity epidemic. Therefore, one of the primary prerequisites for the classification of policy tools in this article is that the attributes and functions of policy tools must be more clarified, so that the maximum effectiveness of different policy tools can be reasonably brought into play. Based on the above analysis process, this article adopts the views of Howlett in the classification of policy tools, combined with the actual situation, divides the policy tools into authoritative policy tools, economic policy tools, health promotion policy tools, and social policy tools. The definitions and functions of these policy tools are shown in Table 1.

Finally, in the selection of different policy tools, this paper argues that there are two basic questions to consider: (1) First, why does the government adopt a certain policy tool but not another, that is, what is the basis for the government to choose policy tools. It is generally believed that operability is a factor that must be considered in the selection of policy tools [44], which determines whether the policy tools themselves can be effectively used in a certain type of government or system. But policy tools are not just a technological phenomenon [23], they reflect different intrinsic values and norms [45]. Therefore, the choice of policy tools essentially represents the value preferences of different policy subjects and the actual needs of policy objects; (2) Second, which factors will affect the effectiveness of policy tools. In different types of government and institutional environments, the factors that affect the effectiveness of policy tools are complex and diverse [46]. But in addition to the influence of political background, the effectiveness of policy tools depends on the attributes of policy tools and the policy issues to be solved [47]. Therefore, only when the policy tool matches the policy objective and policy object, the policy tool is effective [48].

3. Materials and methods

3.1. Data and data collection process

From the perspective of event system theory, the COVID-19 epidemic is a novel, critical, and extremely destructive event [49]. This type of event can have a significant impact on the perception and behavior of individuals. In the post-epidemic period, the occurrence of small-intensity epidemic events makes individual perceptions show a process of dynamic changes. In mid-May 2021, during our data collection period, a new round of local epidemics broke out in Liaoning, which instantly touched the nerves of the public. Afterwards, the public’s willingness to vaccinate has obviously improved qualitatively. When news of the outbreak spread, many residents lined up to get vaccinated in communities and hospitals overnight. At the same time, the Chinese government quickly launched emergency response measures and adopted a series of authoritative policy tools including nucleic acid testing for all employees, identification and control of risk areas, shutdowns in some areas, and temporary centralized vaccination. According to Bliese et al. [50], the key events that cause behavioral changes should be studied by comparing measures before and after the event. So in order to further capture the impact of this incident on individual perceptions and the government’s response strategies, we collected data on the same variables after the outbreak in Liaoning.

Since it is difficult to adopt offline nationwide strict probability sampling during the epidemic, this study will collect questionnaires through an online network platform (Questionnaire Star). In order to facilitate the comparative study before and after, when the

| Table 1 | Types, functions and Policy goals of main policy tools. |
|---------|--------------------|--------------------------------------------------|
| type    | Sub-policy tool     | functions                                         | Policy goals                     |
|         |                     | 1. With government authority as a resource, it has standard and guarantee functions | Resolve the crisis               |
| Authority tools | Nucleic acid detection in the whole population restrict the movement of people social distancing stop production Set up temporary centralized vaccination sites Identify and manage risk areas Vaccination in different groups | 2. Generally adopted after the outbreak of a crisis, with strong responsiveness | |
| Economic tools | Vaccination Incentive Subsidy Corporate tax incentives Government financial investment Procurement of medical supplies Free treatment | 3. Higher operating costs | |
| Health promotion tools | COVID-19 vaccine research and development Outbreak infection and vaccination data disclosure Inoculation knowledge promotion Investment in emergency healthcare resources Vaccination staff training wear mask | 1. The main target is mainly production units such as enterprises | Recovery economy |
|          |                     | 2. Generally adopted during the recovery period of the crisis, which is of welfare nature | |
|          |                     | 3. The operating cost is moderate | |
| Social tools | Community worker advocacy Public-private partnership Social mobilization | 1. Mainly supported by social forces, the government plays a leading role; | Both |
|          |                     | 2. Runs through the entire process of crisis response, with moderate operating costs |
sample size after the small-intensity outbreak was basically the same as the sample size before the outbreak, we closed the questionnaire recovery link. The data collection time is mainly concentrated between May 1 and June 12, 2021. Before filling out the questionnaire, the author will inform the respondent that he has the right to withdraw from the survey at any time. All questionnaires are filled out in accordance with the principle of anonymity and voluntariness. At the same time, we will introduce the relevant background knowledge of the epidemic in the first volume. After collecting the questionnaire survey platform, we carried out the similarity test and the filtering process of invalid questionnaire elimination to ensure the quality of the collected questionnaires. Through the above process, we collected a total of 629 questionnaires. According to the feedback data, 312 people (approximately 49.6% of the total sample) filled out the questionnaire before the outbreak, and 317 people (approximately 50.4% of the total sample) filled out the questionnaire after the outbreak. It is generally believed that the sample size in multiple linear regression is at least 5 to 10 times the variable [51], and our sample size also meets this requirement.

3.2. Measurement of variables

3.2.1. Dependent variable

The dependent variable in this article mainly uses the 7-point Likert scale to determine the willingness of individuals to receive the COVID-19 vaccine. On the basis of informing the respondent that the vaccine is free and voluntary, set “Are you willing to go to the community/or designated hospital for vaccination?” The answer ranges from “absolutely willing” = “7” to “absolutely unwilling” = “1” points for assignment.

3.2.2. Independent variables (Level 1)

This article takes the four main components of the health belief model as factors that affect the public’s COVID-19 vaccination. Specifically, it includes the following four dimensions: perceived severity, perceived susceptibility, perceived benefits and Perceived barriers. Each dimension level will be measured through the following questions. In order to understand the true intention of the interviewee, the order of the same measurement questions will be disrupted in the questionnaire. The specific items are as follows:

Perceived severity is the perception of the severity of the risk of COVID-19 infection. It mainly includes “What do you think about the disease of COVID-19 ?”, “Are you worried about being infected (or re-infected the disease after recovering from the infection)?”, “My health is very good, and the risk of contracting the COVID-19 virus is very low.”, “The COVID-19 epidemic in my area has now eased, and there is no need to vaccinate the COVID-19 vaccine.” According to the Likert five-point scale, the answer to each question is scored from “1” to “5” according to the severity. Then calculate the average score for each question.

Perceived susceptibility refers to the degree of susceptibility to the safety and effectiveness of COVID-19 vaccination. It mainly includes three questions: “How often do you pay attention to the COVID-19 vaccine in the near future?”, “I am very worried about the effectiveness of the COVID-19 vaccine”, and “I am worried about the possible side effects of the COVID-19 vaccine”. According to the Likert five-point scale method, the answer to each question is assigned points from “1” to “5” according to the degree of susceptibility. Then calculate the average score for each question.

Perceived benefits refer to the perception of the benefits that may be obtained from the COVID-19 vaccine. Mainly include “vaccinating the COVID-19 vaccine is very important to my health”, “vaccinating the COVID-19 vaccine can protect the people around me (family, friends, colleagues) from infection”, “under the government’s publicity and encouragement policy, I believe that the

| Variable type      | Variable name                | measurement standard                      | Mean  | SD    | CR    | AVE  |
|--------------------|------------------------------|------------------------------------------|-------|-------|-------|------|
| Independent variable | Perceived severity       | Perception of the severity of the risk of new coronavirus infection, See above for specific calculation method. | 3.93  | 0.537 | 0.78  | 0.54 |
|                     | Perceived susceptibility  | susceptibility to the safety and effectiveness of new crown vaccination, see above for specific calculation methods. | 3.13  | 0.762 | 0.77  | 0.53 |
|                     | Perceived benefits        | For the perception of the possible benefits of vaccinating the new crown vaccine, see the specific calculation method above. | 4.01  | 0.598 | 0.77  | 0.53 |
|                     | Perceived barriers        | The perception of the obstacles faced by the new crown vaccine, the specific calculation method is shown above. | 3.14  | 0.898 | 0.85  | 0.66 |
| Control variable    | Sex                         | Male = “1”; female = “2”.                 | 1.53  | 0.500 | –     | –    |
|                     | Age                        | <18 years old = “1”; 18-25 years old = “2”; 26-44 years old = “3”; 45-59 years old = “4”; over 60 years old = “5”. | 2.66  | 0.884 | –     | –    |
|                     | Race                       | Han nationality = “1”; minority nationality = “2”. | 1.06  | 0.244 | –     | –    |
|                     | Region                     | Urban area = “1”; suburban area = “2”; rural area = “3”. | 1.83  | 0.949 | –     | –    |
|                     | Education                  | Junior high school degree or below = “1”; High school diploma = “2”; bachelor degree = “3”; master’s degree and above = “4”. | 2.79  | 0.975 | –     | –    |
|                     | Income                     | <5000 yuan = “1”; 5001-10000 yuan = “2”; 10001-20000 yuan = “3”; > 20000 yuan = “4”. | 1.66  | 0.809 | –     | –    |
|                     | Self-rated health           | Very good = “5”; relatively good = “4”; general = “3”; relatively poor = “2”; very poor = “1”. | 4.23  | 0.762 | –     | –    |
|                     | Date                       | Before the small-intensity epidemic occurs, the value is “1”; after that, the value is “0”. | 0.500 | 0.500 | –     | –    |
| Dependent variable  | Intention                  | Willingness to go to the community or designated hospitals for vaccination. From “absolutely willing” = “7” points, to “absolutely unwilling” = “1” points for assignment. | 4.59  | 1.234 | –     | –    |
COVID-19 vaccination are beneficial” three items. According to the Likert five-point scale, the answer to each question is scored from “1” to “5” according to the degree of benefit. Then calculate the average score for each question.

Perceived barriers refer to the perception of obstacles faced by the COVID-19 vaccine. It mainly includes: “I feel very difficult to go to the community/hospital to get the COVID-19 vaccination”, “My opinion on making an appointment for the COVID-19 vaccine”, “My opinion on queuing up to the community/hospital for vaccination?” Three items. According to the Likert five-point scale method, the answer to each question is assigned points from “1” to “5” according to the degree of obstacle. Then calculate the average score for each question.

The reliability and validity test results of the measurement tools are shown in Table 2 below. As mentioned above, the perceived severity, perceived sensitivity, perceived benefit, and perceived impairment used in this paper are all combined variables, so we conducted a combined reliability analysis, and the final results were all between 0.77 and 0.85, which was higher than the standard value of 0.7 [52], showing good internal consistency of the measurement of each variable. Validity reflects the true degree of measuring things, and this paper mainly reflects it through the convergent validity of variables. Through the average variance extraction value test, it is found that the AVE value of the variable is between 0.53 and 0.66, which is higher than the standard value of 0.5 [53], indicating that each variable can explain more than 50% of the variance of the observed variable on average, and the convergence validity is good.

3.2.3. Control variables (Level 2)

This article takes the individual’s age, gender, region, education level, income, and self-rated health status as control variables. The definition and descriptive statistical analysis of each variable are shown in Table 2.

A total of 629 questionnaires were collected in this survey, of which male respondents accounted for 47.1%, with a relatively balanced ratio of males and females; 55% of the respondents were from urban areas, and most of the remaining respondents were from rural areas (accounting for 37.5%), and fewer respondents came from suburban areas; from the perspective of the educational level of the respondents, those with a bachelor’s degree accounted for the highest proportion, reaching 42.4%, followed by those with a master’s degree or above. Respondents, accounting for 25.4%, the least number of respondents were those with junior high school education and below, accounting for 13.8%; in terms of income, the respondents of low- and middle-income groups were higher, and the high-income groups were interviewed are lower. The demographic characteristics of the sample are shown in Table 3 below.

3.3. Method

In order to explore the impact of each health belief component on individual vaccination willingness, this paper constructs the following multiple linear regression model.

\[ Y_i = a_0 + a_1 Controls_i + a_2 perse_{se} + a_3 perse_{su} + a_4 perse_{be} + a_5 perse_{ba} + \epsilon_i \]  \hspace{1cm} (1)

Among them, the dependent variable " \( Y_i \) " represents the inoculation willingness of the i-th sample; " \( Controls_i \) " represents a series of control variables; " \( perse_{se} \), \( perse_{su} \), \( perse_{be} \), \( perse_{ba} \) " respectively represent the four health belief components (perceived severity, severe susceptibility, perceived benefits, Perceived barriers); " \( \epsilon_i \) " represents the random error term; " \( a_1 \sim a_5 \) " is the regression coefficient. In order to further investigate the interaction mechanism between the components of health beliefs and the individual’s perception changes before and after small-intensity epidemic, this paper builds the following model on the basis of formula 1:

\[ Y_i = a_0 + a_1 Controls_i + a_2 perse_{se} + a_3 perse_{su} + a_4 perse_{be} + a_5 perse_{ba} + a_6 perse_{se} \times perse_{su} + a_7 perse_{se} \times perse_{be} + a_8 perse_{su} \times perse_{be} + a_9 perse_{se} \times perse_{su} \times perse_{be} + u_i \]  \hspace{1cm} (2)

\[ Y_i = a_0 + a_1 Controls_i + a_2 perse_{se} + a_3 perse_{su} + a_4 perse_{be} + a_5 perse_{ba} + a_6 Date \times perse_{se} + a_7 Date \times perse_{su} + a_8 Date \times perse_{be} + a_9 Date \times perse_{ba} + \epsilon_i \]  \hspace{1cm} (3)

\[ Y_i = a_0 + a_1 Controls_i + a_2 perse_{se} + a_3 perse_{su} + a_4 perse_{be} + a_5 perse_{ba} + a_6 perse_{se} \times perse_{su} + a_7 perse_{se} \times perse_{be} + a_8 perse_{su} \times perse_{be} + \delta_i \]  \hspace{1cm} (4)

Formula 2 is based on formula 1, which adds the impact of the pairwise interactions between the components of health beliefs on the public’s willingness to vaccinate; Formula 3 is based on formula 1, adding the components of interview time and health beliefs.

### Table 3

Summary of sample demographic characteristics (n = 629).

| project category | N(%) | project category | N(%) |
|------------------|------|------------------|------|
| Sex              |      |                  |      |
| male             | 296(47.1%) | Education        | 87(13.8%) |
| female           | 333(52.9%) | High school diploma | 115(18.3%) |
| less than 18 years | 0(0%) | bachelor degree | 267(42.4%) |
| 18–25 years      | 363(57.7%) | master’s degree and above | 160(25.4%) |
| 26–44 years      | 139(22.1%) | <5000 yuan | 329(52.3%) |
| 45–59 years      | 103(16.4%) | 5001-10000 yuan | 203(32.3%) |
| over 60 years    | 24(3.8%) | 10001-20000 yuan | 78(12.4%) |
| Region           |      | Race             |      |
| Urban area       | 346(55.0%) | Han nationality | 589(93.6%) |
| suburban area    | 477(75.5%) | minority nationality | 406(4.4%) |
| rural area       | 236(37.5%) |                  |      |

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[52]: Citation or reference
[53]: Citation or reference
interaction term explores the differences in individual perception changes before and after the outbreak of a small-intensity epidemic and its impact on the willingness to vaccination. Formula 4 is based on formula 1, adding the influence of the three interactions of the two groups of health belief components on the individual’s willingness to vaccinate. All the above operations are realized by SPSS23.0 analysis software.

4. Results
4.1. Empirical analysis results

This article uses hierarchical linear regression to determine the impact factors, and the results are shown in Table 4. Model 1 is a reference model and only adds control variables such as demographic characteristics; Model 2 is based on Model 1 and adds the influence of each component of the health belief model on the public inoculation willingness; Model 3 is based on Model 2 and adds health belief model components Model 4 is based on Model 2, adding a complete model of cross-order interaction between time dummy variables and health belief components; Model 5 is based on Model 2 with health belief components Of the three interactions. Model 1 show that there is a “U”-shaped relationship between education level and vaccination willingness, For people with lower academic qualifications, they have less knowledge about the COVID-19 vaccination, are less sensitive to the safety and effectiveness of the vaccine, and are more likely to accept the vaccination publicity policy. For people with higher education degrees, they have a deeper understanding of the overall development of the epidemic and the important role of vaccination in forming an immune barrier (the perceived benefits are stronger), so their willingness to be vaccinated is also higher; In addition, the results show that the

| Table 4 Regression analysis results. |
|-------------------------------------|
| variables                          | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Level 1                             |         |         |         |         |         |
| Perse                               | 0.589*** (0.052) | -1.168** (0.540) | 0.567*** (0.090) | 1.556*** (0.101) |
| Persu                               | -0.334*** (0.036) | -1.607*** (0.255) | -0.347*** (0.062) | -0.102** (0.102) |
| Perbe                               | 0.419*** (0.049) | -1.049*** (0.330) | 0.374*** (0.086) | 0.803*** (0.086) |
| Perba                               | -0.414*** (0.039) | 0.513** (0.233) | -0.404*** (0.068) | -0.770*** (0.111) |
| Interaction effect                  |         |         |         |         |         |
| Perse × Persu                       | -0.3459*** (0.0372) |              |              |              |
| Perse × Perbe                       | 0.2098*** (0.0451) |              |              |              |
| Date × Perse                        | -0.1247*** (0.0282) |              |              |              |
| Date × Persu                        | 0.2853*** (0.0733) |              |              |              |
| Date × Perbe                        | 0.0060 (0.0579) |              |              |              |
| Date × Perba                        | 0.2068 *** (0.0674) |              |              |              |
| Perse × Perse × Perba               |          | 0.1334 ** (0.0665) |              |              |
| Control variable                    |         |         |         |         |         |
| Sex                                 | 0.538*** (0.093) | -0.024 (0.025) | 0.015(0.024) | 0.172* (0.093) | 0.016 (0.024) |
| Age                                 | 0.093(0.057) | 0.001(0.015) | -0.002(0.014) | 0.038 (0.062) | 0.008 (0.014) |
| Race                                | 0.312(0.189) | -0.073(0.050) | -0.038(0.046) | 0.205 (0.192) | -0.045 (0.045) |
| Region                              | 0.062(0.052) | 0.013(0.014) | 0.029**(0.013) | 0.015 (0.054) | 0.019 (0.013) |
| Education                           | -0.362*** (0.079) | -0.018(0.021) | -0.012 (0.019) | -1.658*** (0.290) | -0.007 (0.19) |
| Education²                          | 0.047*** (-0.015) | -0.003 (0.004) | 0.001*** (0.054) | 0.301*** (0.004) | 0.001 (0.15) |
| SRH                                 | -0.333*** (0.062) | -0.038**(0.017) | -0.034** (0.015) | -0.078 (0.061) | -0.27* (0.14) |
| Income                              | 0.169*** (0.058) | -0.020(0.016) | -0.029** (0.014) | 0.085 (0.057) | -0.21 (0.14) |
| Adjusted R²                         | 0.130 | 0.940 | 0.950 | 0.951 | 0.951 |
| F value                             | 12.699*** | 623.166*** | 41.487*** | 34.462*** | 64.644*** |
| N                                   | 629 | 629 | 629 | 629 | 629 |

Note: “***”, “**” and “*” in the table indicate significant at the level of “1%”, “5%” and “10%” respectively.
willingness of female groups to vaccinate is significantly higher than that of males, which is consistent with the study of Musha Chen et al. [54]. The possible reason is that female groups have higher risk perceptions. There is a positive correlation between income level and public willingness to vaccinate. High-income groups may suffer greater loss of resources from being infected with the COVID-19 and are more likely to adopt active health behaviors.

Model 2 adds the impact of the four components of the health belief model on the public’s willingness to vaccinate. The results show that both the perceived severity and the perceived benefits are positively significant at the 1% level. When an individual feels a high risk of infection or the individual perceives that vaccination is more beneficial to their health, their willingness to vaccinate is stronger; the two indicators of perceived susceptibility and perceived barriers are both negatively significant at the 1% level. When the public is more concerned about the safety and effectiveness of the vaccine, they are more sensitive to vaccination behavior; the perceived barrier is the individual’s perception of the difficulties encountered during the vaccination process, such as difficulty in making appointments, long queues, etc. The stronger the sense of barriers to vaccination, the lower the willingness to vaccination. Among the four indicators, the perceived severity coefficient is the highest (b = 0.589), indicating that the individual’s willingness to inoculate varies most strongly with the perceived severity.

Model 3 adds the influence of the interaction mechanism of four health belief components on the public’s willingness to vaccinate. Taking the perceived severity as the key independent variable, we explored the moderating effects of three variables: perceived susceptibility, perceived benefits, and perceived barriers. The results show that there is a negative antagonism between the perceived severity and perceived susceptibility. But the public’s willingness to vaccinate still rises with the increase in perceived severity; there is a positive promoting effect between the perceived severity and the perceived benefits. The willingness to inoculate under the high level of perceptual benefit adjustment is always stronger than the willingness to inoculate under the low level of perceptual benefit adjustment; there is a negative antagonism between the perceived severity and the perceived barriers, and the willingness to inoculate under the low perceived barriers adjustment level is always stronger than the high perceived barriers adjustment level. Regardless of whether it is a low level of regulation or a high level of regulation, the public’s willingness to inoculate increases with the continuous increase in perceived severity. The specific changes in inoculation willingness are shown in Fig. 2. In general, the adjustment coefficient between the perceived severity and perceived susceptibility is the highest (b = −0.3459, P = 0.000), while the perceived severity and perceived benefit show a positive adjustment (b = 0.2098, p = 0.000). This means that in an environment where individuals perceive high susceptibility and low perceptual severity, the public’s willingness to vaccinate will be very low. In environments with high perceived severity and high perceived benefits, the public’s willingness to vaccinate is the highest.

Fig. 2. The effect of $2 \times 2$ interaction of health belief components.
Model 4 shows that only the three variables of perceived severity, perceived barriers, and perceived benefits have significant regulatory effects, while the perceived susceptibility is not significant, which indicates that the small-intensity epidemic does not affect the individual’s perceived changes in susceptibility to vaccination. The specific changes in perceived severity, perceived benefits, and perceived barriers are shown in Fig. 3 below.

It can be seen that the outbreak of a small-intensity epidemic has exacerbated the impact of these three health belief components on the willingness to vaccination. After the occurrence of a small-intensity epidemic, the severity of individual perceptions and perceived benefits have increased significantly. According to the “gain paradox principle” [55], the significance of resource income will greatly increase in the context of resource loss. Therefore, in the face of high risk (like COVID-19 epidemic), “gain resources” has become an inducing factor to encourage people to take active actions to protect future resource losses, and the public’s willingness to vaccinate has greatly increased [21]. However, with the rapid increase in the number of vaccinated persons, in the short term, it will bring new pressure on the series of vaccination measures adopted by the government in the early stage, resulting in difficulties in making appointments and queuing, which in turn raises public perceived barriers and reduces the public’s willingness to vaccinate.

Model 5 uses the two health belief components of perceived severity and perceived barriers as a benchmark, and explores the interaction mechanism of adding the perceived susceptibility and perceived benefit respectively. The reason for selecting these two groups of health belief components is that the perceived severity is a key indicator that affects an individual’s willingness to vaccinate, and perceived barriers are the main negative factor after a small-intensity outbreak. The results show that both groups of components have a significant positive effect. The specific changes are shown in Fig. 4.

It can be seen that the public’s willingness to vaccinate has a greater change under the adjustment levels of high and low perceived susceptibility. Although the small-intensity outbreak did not significantly increase (decrease) the susceptibility of public perception, it seems to provide useful help for the government’s strategic choices on a theoretical level. Before the outbreak of a small-intensity epidemic, the government should adopt a series of policy tools to reduce the public’s perception of sensitivity, thereby increasing the public’s willingness to vaccinate.

4.2. The choice of Chinese government policy tools

Table 5 below shows the combination of Chinese government policy tools before and after the outbreak of small-intensity epidemic in the post-epidemic period. It can be seen that the mix of policy tools employed by the Chinese government has been changing. This
change is mainly to adapt to changes in policy objectives and public risk perceptions under different crisis scenarios.

Before the outbreak of the small-intensity epidemic, the number of COVID-19 infections in China continued to decline, and social control was gradually relaxed. During this period, the main task of the Chinese government was to restore economic production. Therefore, economic policy tools became the main choice of the Chinese government, while the number of authoritative policy tools was greatly reduced [24]. The Chinese government has pushed the Chinese economy to quickly get on the right track by promoting

Table 5
The combination of policy tools used before and after the epidemic.

| policy tool                      | Sub-policy tool                                      | outbreaks of the small-intensity epidemic |
|---------------------------------|-----------------------------------------------------|------------------------------------------|
| Authoritative policy tools      |                                                     | Before After                             |
| Nucleic acid detection in the whole population | + ++                                                 |                                          |
| restrict the movement of people | + ++                                                 |                                          |
| social distancing               | + ++                                                 |                                          |
| stop production                 | − ++                                                 |                                          |
| Set up temporary centralized vaccination sites | − ++                                                 |                                          |
| Identify and manage risk areas  | + ++                                                 |                                          |
| Vaccination in different groups | + ++                                                 |                                          |
| Economic policy tools           |                                                     |                                          |
| Vaccination Incentive Subsidy   | + ++                                                 |                                          |
| Corporate tax incentives        | + +                                                  |                                          |
| Government financial investment | + ++                                                 |                                          |
| Procurement of medical supplies | + +                                                  |                                          |
| Free vaccination                | + ++                                                 |                                          |
| Health promotion policy tools   |                                                     |                                          |
| COVID-19 vaccine research and development | + +                                                  |                                          |
| Outbreak infection and vaccination data disclosure | + +                                                  |                                          |
| Inoculation knowledge promotion | + +                                                  |                                          |
| Investment in emergency healthcare resources | + +                                                  |                                          |
| Vaccination staff training      | + +                                                  |                                          |
| wear mask                       | + +                                                  |                                          |
| Social policy tools             |                                                     |                                          |
| community worker advocacy       | + +                                                  |                                          |
| public-private partnership      | + +                                                  |                                          |
| social mobilization             | + +                                                  |                                          |

Note: "++" means more use; "+" means less use; "--" means no use. Data compiled by the author from the official website of the central government.
consumption and employment of the people and providing preferential tax and fee policies to enterprises [56]. In terms of epidemic prevention and control, health promotion tools are the main type of policy tools adopted by the Chinese government. Before the outbreak of this small-intensity epidemic, vaccine hesitancy was a difficult problem faced by China in the vaccination process [57]. Therefore, on the one hand, the Chinese government is constantly accelerating the research and development and testing of the COVID-19 vaccine to reduce the public’s concerns about the safety and effectiveness of the vaccine [58], and on the other hand, the Chinese government is constantly promoting the benefits of the new crown vaccination to the public through a combination of online and offline methods and the dangers of contracting the new crown virus, promote public vaccination against the new crown virus [59].

After the outbreak of the small-intensity epidemic, the number of people in China’s new crown infected rises in the short term. In order to quickly solve the crisis, the Chinese government adopted a combination of policy tools with authoritative policy tools. According to the activity trajectory of the infected person, the Chinese government divides the territory control of “sealing area”, “control area”, “defense area” [60]. Residents in the “sealing area” must be concentrated or home isolation medical observations; in the “control area” residents, they do not allow leaving “control zone” before universal, and do not allow crowds to gather. In the “defense area” resident, it is required to prepare for epidemic prevention, and travel must bring a mask, and do not allow large-scale gathering of people. At the same time, in order to prevent the epidemic from further spreading, the Chinese government quickly took the residents of the control area to detect the nucleic acid detection of all populations.

With the surge in COVID-19 infection, many resident vaccination will continue to rise. When the news of the new round of epidemic is spread in China, many vaccination points have risen the long team. In order to adapt to this change, the Chinese government has also adjusted the use of economic policy tools, put more resources into the production and distribution of emergency medical and health resources. At the same time, a temporary centralized vaccination point has been set up to meet the public’s vaccination needs. In addition, the Chinese government also encourages the public volunteers to participate in the prevention and control work in the form of social mobilization. These volunteer teams play an important role in the prevention and control of epidemic [61].

5. Discussion

This study adds to the existing literature on public health event governance in the post-pandemic era. By analyzing relevant data, we strengthen our understanding of the dynamic evolution of public health risks and the choice of government policy tools in the post-pandemic period.

Public risk perception research is one of the important topics that scholars pay attention to in public crisis governance [62–64]. Since the COVID-19 pandemic, many scholars have used the health belief model [38,65] and the theory of planned behavior [37] to analyze the public’s health behavior. But these studies have focused on vaccine hesitancy among the general public [66,67] and on the demographics of specific samples [68,69]. With the continuous repetition of the epidemic, the public’s health risk perception also shows a dynamic evolution [70], but the existing research rarely discusses this issue. This paper not only analyzes the public’s health risk perception before and after the small-intensity epidemic, but also further explores the influence of the interaction of different health belief factors on the public’s willingness to vaccinate. We got some interesting findings, such as public perceived susceptibility did not change significantly before and after the small-intensity epidemic [21], but we found in interaction analysis that perceived susceptibility moderates public willingness to vaccinate compared to perceived benefit higher level. This seems to indicate that in the post-epidemic period, the Chinese government can increase the public’s willingness to vaccinate by increasing the research and...
development of the COVID-19 vaccine to reduce the public’s perceived susceptibility than providing the public with preferential policies for vaccination to improve the public’s perceived benefits.

In addition, only analyzing the individual micro-psychological mechanism of the public will easily fall into the trap of studying the “inner world” from the “inner world” [31]. This research method ignores the impact of external interventions such as political systems [71] and policy tools [72] on individual cognition. Excessive demonstration of the guidance of psychological theories and paradigms on individual behavior will make research lacking in dialogue with public management disciplines and practical practices [73]. Therefore, this study attempts to go beyond the analysis of individual micro-psychological mechanisms to strengthen the shaping effect of policy tools on individual cognition and behavior [74]. Specifically, we construct a “perception-goal-tool” analysis framework. Taking the individual’s micro-psychological mechanism as the research starting point, and with the help of the discourse system of policy science, the potential mechanism between the individual’s risk perception and the choice of policy tools is fully explored. The specific results are shown in Fig. 5 below.

It can be seen that the combination of policy tools used by the Chinese government in the post-epidemic period has been constantly changing with the public’s health risk perception and policy goals. Economic policy tools and authoritative policy tools play a key role before and after the outbreak of the small-intensity epidemic. The flexible replacement and matching of the two reflects the flexible governance capability of the Chinese government in epidemic prevention and control in the post-epidemic period. This conclusion is also supported by the research results of Yu Jianxing et al. [24]. However, unlike the existing literature [75–77] that evaluates the selection results and effects of policy tools, this study focuses more on why the government chooses one policy tool over another, that is, the internal logic of policy tool selection. The conclusions also provide a new explanation for the choice of policy tools.

6. Conclusion

This study focuses on the changes of crisis situations before and after the outbreak of small-intensity epidemics, constructs an analytical framework of “perception-goal-tool”, and deeply analyzes the change process of individuals’ health beliefs in the context of crisis and the internal logic of government policy tool selection. We collected relevant data on public risk perception and a series of policy tools adopted by China’s policies from May 1 to June 12, 2021, and used a combination of qualitative and quantitative analysis to demonstrate the dynamic evolution mechanism of public health risk perception. The potential mechanism between government policy tool selection and government policy tool selection enhances the understanding of the internal logic of government policy tool selection, and also provides targeted guidance for public health risk governance in the post-epidemic period.

On the basis of discussing the influence of health belief components on health behavior from a single dimension in the past, this study further analyzes the interaction mechanism between several components of the health belief model on individual health behavior willingness, which broadens the application scope of the health belief model. The study found that in the post-epidemic period, perceived severity was the core factor affecting the public’s willingness to vaccinate, while perceived barriers were the main negative factor affecting public vaccination after a small-intensity outbreak. When a small-scale epidemic broke out, China adopted a combination of policy tools such as “set up temporary centralized vaccination sites and investment in emergency healthcare resources” to reduce the public’s perceived barriers and increase their willingness to be vaccinated. In addition, from the three interactive analyses of perceived severity, perceived barriers, and perceived susceptibility, we found that reducing the public’s perceived susceptibility also had a significant impact on increasing the public’s willingness to vaccinate. This has important reference value for those areas with large population or lack of medical and health resources.

Of course, this study also has some limitations. (1) as an exploratory study, we collected relevant data before and after small-intensity outbreaks, but we cannot guarantee strict probability sampling. For example, 67.8% of our respondents have a bachelor’s degree or above, which greatly exceeds the national average [78] and affects the representativeness of the sample. (2) This article focuses on the changes before and after the small-intensity epidemic in May 2021, but does not further track the Chinese government’s policy tools and public risk perceptions in the post-epidemic rounds of the epidemic from a longer time chain. Future research can further analyze from this direction. (3) the conclusions of this paper may be more helpful for enriching the public crisis management methods of the unitary centralized countries and regions. Because the flexible selection of policy tools and the promotion of authoritative policy tools often require strong national mechanisms as support.

Data availability statement

The dataset this paper uses is originally collected and owned by Zixuan Liu and Pinghuai Yu. The data can be available only after the owners have completed using the data for their submissions (journal articles and other media outputs). The statistical output that this paper is based on can be available for review, from the corresponding author, upon request.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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