The public health emergency management system in China: trends from 2002 to 2012

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Abstract

Background: Public health emergencies have challenged the public health emergency management systems (PHEMSs) of many countries critically and frequently since this century. As the world’s most populated country and the second biggest economy in the world, China used to have a fragile PHEMS; however, the government took forceful actions to build PHEMS after the 2003 SARS outbreak. After more than one decade’s efforts, we tried to assess the improvements and problems of China’s PHEMS between 2002 and 2012.

Methods: We conducted two rounds of national surveys and collected the data of the year 2002 and 2012, including all 32 provincial, 139 municipal, and 489 county CDCs. The municipal and county CDCs were selected by systematic random sampling. Twenty-one indicators of four stages (preparation, readiness, response and recovery) from the National Assessment Criteria for CDC Performance were chosen to assess the ten-year trends.

Results: At the preparation stage, organization, mechanisms, workforce, and stockpile across all levels and regions were significantly improved after one decade’s efforts. At the readiness stage, the capability for formulating an emergency plan was also significantly improved during the same period. At the response stage, internet-based direct reporting was 98.8%, and coping scores were nearly full points of ten in 2012. At the recovery stage, the capabilities were generally lower than expected.

Conclusions: Due to forceful leadership, sounder regulations, and intensive resources, China’s PHEMS has been improved at the preparation, readiness, and response stages; however, the recovery stage was still weak and could not meet the requirements of crisis management and preventive governance. In addition, CDCs in the Western region and counties lagged behind in performance on most indicators. Future priorities should include developing the recovery stage, establishing a closed feedback loop, and strengthening the capabilities of CDCs in Western region and counties.

Keywords: Public health emergency management system, China, Trend, Preparation, Readiness, Response, Recovery

Background
Since the early twenty-first century, frequently appearing public health emergencies such as severe acute respiratory syndrome (SARS), Middle Eastern respiratory syndrome, and Ebola have threatened population health and social stability [1]. This has critically challenged the public health emergency management systems (PHEMSs) of many countries [2], especially developing countries. The global community quickly reached a consensus on the development of the PHEMSs [3]. In 2005, the 58th World Health Assembly (WHA) adopted the revised International Health Regulations, which instructed the World Health Organization (WHO) member states to collaboratively confront public health emergencies of global concern. A World Health Report in 2007 also focused on global public health security in the twenty-first century. The Ebola outbreak in 2014–2015 has pushed the process of WHO reform into high gear [4], giving top priority to changes in...
the WHO’s emergency operations and a need to build resilient health systems that can withstand epidemics.

China has the largest population and the second biggest economy in the world. China has played an increasingly important role in preventing and controlling the global spread of epidemics in recent years and gradually changed from aid recipient to aid donor [5]. China used to have a fragile PHEMS; however, the 2003 SARS outbreak exposed many weaknesses and problems [6], such as an ineffective response system, lagging epidemiological field investigation and laboratory testing skills, and inaccurate and untimely information communication. These aroused the public’s horror and international community’s blame. The central government urged governments at different levels to make political commitments and take forceful actions to build the PHEMS.

After more than one decade’s efforts, what are the trends of China’s PHEMS? What are the improvements and remaining problems? What are the implications for China and global health security? In recent years, the development of PHEMS has received increased attention in the literatures. Some researchers expressed the importance of PHEMS and the progress after SARS qualitatively [7, 8]. Others quantitatively accessed the trends using regional data, usually at a certain level or within a certain province or city [9–12]. Time spans were restricted to early-phase usually around 2005 [13]. To our knowledge, little evidence could tell the differences that happened in China’s PHEMS in this decade.

Based on two national surveys in 2006 and 2013, we previously reported that resource allocation of CDCs increased and the general completeness of PHEMS improved between 2002 and 2012 [14]. However, what measures PHEMS carried out and how it changed still remained unclear. This paper will attempt to answer these questions specifically.

This article consists of the follows. The next section provides details on methodology, including sampling, indicator selection and measurements, data collection, and data analysis methods. The third section shows the results, followed by discussion corresponding to the results. The final section is about conclusion and policy implications.

**Methods**

**Sample**  
The survey methods have previously been published [14]. Briefly, we conducted two rounds of cross-sectional surveys in 2006 and 2013. The two surveys were retrospective and selected the same agencies in the two rounds. The survey of 2006 collected the data from 2002 to 2005, and the survey of 2013 collected data of 2012. We conducted a multi-stage sampling to select CDCs at different administration levels, selected all 32 provincial CDCs and used systematic random sampling to select municipal and county CDCs. As governmental funding is the most critical control point of public health emergency management for the CDCs [15], we used “governmental funding to CDCs per thousand people” as a basis to determine sample size [16]. A sample size of 123 municipal and 457 county CDCs was calculated based on the following formula [17].

\[
 n = \left[ \frac{(\mu_1 + \mu_2) \times \sigma}{\delta} \right]^2
\]

where \( n \) is the number of the minimal sample size; \( \mu \) is the probability of type I error; \( \beta \) is the probability of type II error, here \( \alpha = 0.05, \beta = 0.05 \); \( \mu_1 \) and \( \mu_2 \) are standard normal distribution values corresponding to \( \alpha \) and \( \beta \) respectively; \( \sigma \) is the population standard deviation, here \( \sigma = 404.3 \) yuan; \( \delta \) is the allowable error. For municipal CDCs, \( \delta = 54.9 \) yuan, \( \sigma = 210.0 \) yuan. For county-level CDCs, \( \delta = 62.5 \) yuan, \( \sigma = 404.3 \) yuan (1 U.S. dollar = 6.6 yuan).

The municipal and county level CDCs were all selected through random sampling. The sampling process was conducted based on the national standard coding (GB coding, the corresponding administrative regional code which is unique for each city or county [14]). We used a computer-generated random number to identify the first institution, and then selected every third municipal CDC and every sixth county level CDC. Finally, we selected 32 provincial CDCs, 139 municipal CDCs, and 489 county CDCs.

The study was approved by the former Ministry of Health (MOH) in China and reviewed by the Medical Research Ethics Committee at the School of Public Health of Fudan University.

**Measures**  
We selected twenty-one indicators associated with the PHEMS from the National Assessment Criteria for CDC Performance. Based on the crisis management theory which was commonly used in the field of public emergency management [18, 19], the whole process was divided into four stages including preparation, readiness, response and recovery [20]. According to the framework, we grouped the indicators into 4 stages and 13 capabilities. Table 1 showed the features, units and measurements of these indicators.

According to the National Regulations on Public Health Emergency Management [21], each sampled CDC graded five public health emergencies handled in the year before the survey with the full mark of 10 points for each indicator; at CDCs where the total numbers of handled public health emergencies were fewer than five, all public health emergencies were graded instead.

**Quality control**  
The Bureau of Disease Prevention and Control of the former MOH approved and organized two rounds of
field surveys, and 32 provincial Health Departments co-
ordinated data collection.

A pilot survey was conducted to ensure validity and
reliability. After receiving uniform training from the
MOH, the provincial quality supervisors trained investi-
gators from sampled CDCs in their corresponding prov-
inces. The investigators collected relevant data from
sampled CDCs and submitted the completed question-
naires to their provincial quality supervisors via e-mail
or CD-ROM. Simultaneously, paper copies with official
stamps were submitted.

The second round of survey data were obtained from
National Disease Control and Prevention Performance
Evaluation Platform. The quality control process was set
up and carried out by the platform with backend logic
judgments and audit procedures.

As the final step of quality control in both surveys, re-
search group rechecked data and contacted CDCs with
abnormal or absent values via email or phone. Finally,
the overall response rate was 95.8% in 2002 and 99.5%
in 2012.

Data analysis
We established a dataset using Excel 2013(Microsoft
Redmond WA). We only used the data of the year 2002
and 2012 for analysis. After data cleaning and sorting,
descriptive analysis and statistical tests were performed
using SPSS 21.0 (IBM SPSS, Chicago, IL, USA). We used

| Stage | Capability | Indicator | Unit | Response measurement and indicator calculation |
|-------|------------|-----------|------|-----------------------------------------------|
| 1. Preparation | 1.1 Organization | Percentage of establishing emergency response office | % | yes/no; number of CDCs’ responses/sample size |
| | | Percentage of forming leadership group | % | |
| | | Percentage of forming expert panel | % | |
| | 1.2 Mechanisms | Percentage of building information sharing mechanism | % | |
| | | Percentage of building on-site treatment mechanism | % | |
| | | Percentage of building material deployment mechanism | % | |
| | 1.3 Workforce | Average number of emergency response personnel | Person | number; total number of personnel/sample size |
| | 1.4 Stockpile | Percentage of fully stockpiling emergency resources | % | yes/no; number of stockpiling emergency resources/fully stockpiling emergency resources |
| 2. Readiness | 2.1 Planning | Percentage of formulating emergency response plan | % | yes/no; number of CDCs’ responses/sample size |
| | 2.2 Training | Average length of emergency response training | Day/person | total days of emergency response training/total emergency response personnel |
| | 2.3 Exercising | Average times of exercises of emergency response plan | Number of times | total times of exercises/sample size |
| | 2.4 Monitoring | Disease surveillance and analytical period | Frequency | by day, week, ten days, month, quarter, year |
| | 2.5 Direct report | Percentage of internet direct report building | % | number; number of internet direct reports/total reports |
| 3. Response | 3.1 Reporting | Percentage of timely reporting | % | number; number of timely reports/total reports |
| | 3.2 Coping | Confirmation Score | Points | Ten-point scale, full points of 10 = good; Total scores/sample size |
| | | Specific Preparedness Score | Points | |
| | | On-scene/field handling/disposal score | Points | |
| | | Implementation score for control measures | Points | |
| 4. Recovery | 4.1 Archiving | Archive of relevant materials | Points | |
| | 4.2 Analyzing | Analytical report and impact evaluation | Points | |
| | 4.3 Concluding | Concluding report | Points | |

Note: CDC means Center for Disease Prevention and Control.
McNemar’s test to test differences in proportions and paired sample t test to test differences in means between 2002 and 2012. Since noticeable differences existed between China’s regions, the division of regions was based on the 2003 Chinese Economics Yearbook and the First National Economic Census.

Results

Preparation stage
Establishing organization comprised building an emergency response office and forming a leadership group and an expert panel. The average percentage of CDCs with an emergency response office was 61.6% in 2002 and 95.0% in 2012. The average percentages with a leadership group and an expert panel were 47.9% and 78.6% in 2002 and 95.7% and 96.8% in 2012, respectively. Similar trends also occurred across different levels and regions (Table 2).

The capability for building mechanisms in terms of information sharing and on-site treatment increased by 93.5% and 89.4%, respectively. Increasing by 127.5%, response-material deployment mechanism gained the highest growth rate. Municipal CDCs had the highest percentages, followed by provincial and county CDCs. The central region not only had the highest percentages, but also experienced the highest growth rate.

Average number of emergency response personnel per CDC increased from 15 in 2002 to 31 in 2012, which was significant. In 2012, provincial CDCs had the highest number of personnel (n = 92), followed by municipal (n = 47) and county (n = 22) CDCs. Moreover, the average number decreased from eastern (n = 35) to western regions (n = 29) (Table 3).

The percentage of fully stockpiling emergency resources significantly increased from 16.7% in 2002 to 41.2% in 2012. Provincial CDCs had the highest percentage (74.2%) in 2012 and increased by 102.2%, whereas county CDCs had the lowest percentage (34.5%) in 2012 and increased by 141.3%. Nevertheless, the average percentage at each administrative level did not meet the corresponding performance assessment criteria. Average percentages of fully stockpiling emergency resources decreased from eastern (56.7%) to western (31.7%) regions.

Readiness stage
The mean percentage of formulating emergency plan increased from 40.6% in 2002 to 89.9% in 2012, statistically significantly increasing by 121.4%. Provincial CDCs had the highest percentage (93.5%) in 2012, and the difference between municipal (89.1%) and county CDCs (89.9%) was not significant. CDCs in central region had the highest percentage (92.5%), followed by western (89.2%) and eastern (86.0%) regions (Table 2).

The average length of emergency response training increased from 9.7 days per person in 2002 to 14.6 days per person in 2012; however, this 50.5% increase was not statistically significant. Provincial CDCs had the highest average length of response training (44.3 days per person), followed by municipal and county CDCs (Table 3).

Comparing the statistics in 2002 and 2012, the average times of exercises did not change with statistical significance. In 2012, county CDCs had higher average times of exercises than did municipal (1.7) and provincial (1.5) CDCs; nevertheless, only provincial CDCs had increased average times of exercises during the past decade. From regional perspective, the average times of exercises decreased from western (2.7) to eastern (1.8) regions (Table 3).

There were 63.7% and 23.0% of disease surveillances conducted per month and per week in 2012, respectively. Compared with statistics in 2002, frequencies of daily, weekly, and monthly surveillance analysis increased, among which weekly surveillance analysis increased with statistical significance. Meanwhile, the frequencies of disease surveillance analysis per ten days, quarter, and year decreased with statistical significance (Table 2).

Response stage
According to “contingency rules of paroxysmal public health events”, public health emergency events are classified into four levels (I, II, III and IV), with severity decreasing from Level I to Level IV. In 2012, there were 3092 public health emergencies directly reported via the Disease Surveillance Information Management System, which accounted for 98.8%. The percentage of timely reporting by county CDCs emergency levels in 2012 was presented in Table 4. Moreover, the average scores for indicators of coping capability were high in 2012 (Table 4).

Recovery stage
The average scores for capabilities at recovery stage were lower than those for capabilities at response stage. The average score for data archiving was 8.33, then followed by those for data analyzing (5.83) and concluding (5.69) (Table 5).

Discussion
The main findings indicated that China had made significant progress in the four stages after a decade’s efforts, especially in preparation, readiness, and response stages. This has been demonstrated by other researches [7, 8].

The average percentages of CDCs with an emergency response office, a leadership group and an expert panel were 95.0%, 95.7% and 96.8% in 2012, respectively. This suggests that a PHPM system with better leadership has been established in China. Soon after the SARS outbreak, Chinese governments at different levels were urged to establish a SARS headquarters at CDCs to shoulder the responsibilities of unified leadership and command during public health emergencies. The Emergency Response Law of the People’s Republic of China
### Table 2: Evaluation of preparation and readiness stage by levels and regions: 2002 and 2012 (differences in proportions)

| Indicators                                      | 2002          | 2012          | Growth (%) | p-value |
|------------------------------------------------|---------------|---------------|------------|---------|
| % of establishing emergency response office    |               |               |            |         |
| Provincial                                     | 632 61.6      | 644 95.0      | 54.2       | 0.5110  |
| Municipal                                      | 29 64.3       | 31 96.8       | 50.5       | 0.0310  |
| County                                         | 135 56.3      | 138 96.4      | 71.2       | 0.0080  |
| East                                           | 468 51.1      | 475 94.5      | 84.9       | 0.1560  |
| Central                                        | 124 55.6      | 129 93.0      | 67.3       | 0.1040  |
| West                                           | 254 54.7      | 255 97.6      | 84.9       | 0.6910  |
| % of forming leadership group                  |               |               |            |         |
| Provincial                                     | 632 47.9      | 644 95.7      | 99.8       | <0.0001 |
| Municipal                                      | 29 78.6       | 31 96.8       | 23.2       | 0.0210  |
| County                                         | 135 47.4      | 138 97.1      | 104.9      | <0.0001 |
| East                                           | 468 46.2      | 475 95.2      | 106.1      | <0.0001 |
| Central                                        | 124 53.2      | 129 93.8      | 76.3       | <0.0001 |
| West                                           | 254 49.4      | 260 93.5      | 89.3       | 0.5860  |
| % of forming expert panel                      |               |               |            |         |
| Provincial                                     | 632 78.6      | 644 96.8      | 23.2       | <0.0001 |
| Municipal                                      | 29 82.1       | 31 93.5       | 13.9       | 0.1090  |
| County                                         | 135 38.5      | 138 96.4      | 150.4      | <0.0001 |
| East                                           | 468 30.6      | 475 84.0      | 174.5      | <0.0001 |
| Central                                        | 124 37.9      | 129 89.1      | 135.1      | <0.0001 |
| West                                           | 254 43.1      | 260 95.0      | 120.4      | <0.0001 |
| % of building information sharing mechanism    |               |               |            |         |
| Provincial                                     | 632 48.0      | 644 92.9      | 93.5       | <0.0001 |
| Municipal                                      | 29 67.9       | 31 93.5       | 37.7       | 0.0060  |
| County                                         | 135 48.9      | 138 96.4      | 97.1       | <0.0001 |
| East                                           | 468 46.6      | 475 91.8      | 97.0       | <0.0001 |
| Central                                        | 124 52.4      | 129 92.2      | 76.0       | <0.0001 |
| West                                           | 254 46.9      | 255 96.1      | 104.9      | <0.0001 |
| % of building on-site treatment mechanism      |               |               |            |         |
| Provincial                                     | 632 49.1      | 644 93.0      | 93.5       | <0.0001 |
| Municipal                                      | 29 79.3       | 31 93.5       | 17.9       | 0.1090  |
| County                                         | 135 48.1      | 138 95.7      | 94.5       | <0.0001 |
| East                                           | 468 47.4      | 475 92.2      | 97.0       | <0.0001 |
| Central                                        | 124 54.8      | 129 91.5      | 124.8      | <0.0001 |
| West                                           | 254 46.9      | 255 95.7      | 104.1      | <0.0001 |
| % of building response material deployment mechanism |           |               |            |         |
| Provincial                                     | 632 39.6      | 644 90.1      | 127.5      | <0.0001 |
| Municipal                                      | 29 67.9       | 31 90.3       | 33.0       | 0.0350  |
| County                                         | 135 39.3      | 138 95.7      | 143.5      | <0.0001 |
| East                                           | 468 38.0      | 475 88.4      | 133.6      | <0.0001 |
| Central                                        | 124 45.2      | 129 91.5      | 102.4      | <0.0001 |
| West                                           | 254 40.2      | 255 93.3      | 132.1      | <0.0001 |
issued in 2007 formally and strongly stipulated the establishment of the emergency management system that urged unified leadership, comprehensive coordination, categorized management, graded responsibility, and territorial management.

The capability for building mechanisms comprised of information sharing, on-site treatment and response-material deployment increased to more than 95% in 2012. Boosted by the SARS outbreak in 2003, various authorities consecutively issued a series of regulations that standardized the PHEMS in terms of macro-level management, professional categories, disposal processes, etc. From the perspective of macro-level management, regulations included emergency management [22], organizational establishment [23], coordination mechanisms [24], etc. From the perspective of professional categories, regulations standardized the responses to nuclear accidents [25], infectious disease outbreaks [26], etc. From the perspective of disposal processes, regulations clearly guided emergency response plans [27], exercising [28], information reporting [29], etc.

Another notable foundation is that the growth of resources including workforce and stockpile was 106.7% and 146.7%, respectively. Since 2003, intensive investments by governments have contributed to the improvements on the following aspects. First, funding for CDCs across different levels changed from balanced allocation to full fiscal funding after 2003. Total income governmental funding increased from 40.75% in 2002 to 63.3% in 2012 [30]. Second, CDCs’ staff were overall more educated. The percentage of staff with bachelor degree or higher increased from 12.7% in 2002 to 29.4% in 2012 [31]. Last, the total value of fixed assets of all CDCs increased from 0.42 billion CN ¥ in 2002 to 12.9 billion CN¥ in 2012 [31]. Available research showed that the quantity and quality of emergency staff, governmental-funding level, and fixed assets played important roles in improving the implementation of CDCs’ capabilities in the PHEMS [15].

A firm leadership, a favorable mechanism and sufficient resources are the key elements of a well-developed PHPMS [32]. It is undeniable that the PHEMS’ achievements in the past decade are remarkable. China’s active and constructive contributions have been highly valued by the global community; for example, China’s response to H7N9 in 2013 was recognized as “exemplary” by the WHO [33]. The three leading guarantees of China could be referenced by developing and other underdeveloped countries.

However, to cope with future challenges in global health security, the following aspects require strengthening. First, preventive governance is necessary. The recovery stage capabilities were the weakest, which is far from achieving the standard of full recovery including sustainability, resilience after crisis and feedback to preparation-stage. The prediction, communication, and social services during and after emergencies require improvement.

Second, balanced development at different regions and levels is very important. County CDCs in the front lines [34] had the weakest capabilities. One possible reason was that the relevant policies including contingency plan, work specifications, and guidelines were not instructive and operable enough for county CDCs [35]. Another reason was an inequitable distribution of personnel in urban and rural areas [36]. Available data showed that compared with

| Indicators | 2002 | 2012 | Growth (%) | p-value |
|-----------|------|------|------------|---------|
|           | n    | %    | n          | %          |          |
| West      | 254  | 36.4 | 260        | 86.2       | 136.8    | < 0.0001 |
| 2.1 Emergency plan | | | | | |
| % of making emergency plans | 632 | 40.6 | 644 | 89.9 | 121.4 | < 0.0001 |
| Provincial | 29  | 42.9 | 31  | 93.5 | 117.9 | < 0.0001 |
| Municipal  | 135 | 38.5 | 138 | 89.1 | 131.4 | < 0.0001 |
| County     | 468 | 41.0 | 475 | 89.9 | 119.3 | < 0.0001 |
| East       | 124 | 35.5 | 129 | 86.0 | 142.3 | < 0.0001 |
| Central    | 254 | 46.1 | 255 | 92.5 | 100.7 | < 0.0001 |
| West       | 254 | 37.5 | 260 | 89.2 | 137.9 | < 0.0001 |
| 2.4 Disease surveillance frequency | | | | | |
| Per day    | 16  | 2.9 | 29 | 4.7 | 62.1 | 0.0400 |
| Per week   | 14  | 2.5 | 141 | 23.0 | 820.0 | < 0.0001 |
| Per ten days | 71 | 12.7 | 10 | 1.6 | –87.4 | < 0.0001 |
| Per month  | 234 | 58.0 | 391 | 63.7 | 9.8 | < 0.0001 |
| Per quarter | 71 | 12.7 | 26 | 4.2 | –66.9 | < 0.0001 |
| Per year   | 63  | 11.3 | 17 | 2.8 | –75.2 | < 0.0001 |
county CDCs, a greater number of personnel with degree higher than bachelor worked at provincial and municipal CDCs [37]. Additionally, the governmental funding per staff for county CDCs in 2012 was 0.1557 million CN¥, which was much lower than the funding at municipal and provincial CDCs (0.2593 and 0.5406 million CN¥, respectively) [38]. From the perspective of regional disparity, CDCs in Western region were the weakest. Reasons include that it had the poorest fiscal capacity to fund CDCs; a limited personnel size; and an inadequate stockpile in terms of working budget, timely reserves, and prompt delivery [39].

Third, the application of new technologies should keep pace with science and technology development. For example, the disease surveillance systems need to be integrated with the use of standard data formats and allow the public health community to respond more quickly to public health threats [40]. A Stockpile Management and Tracking System could also be designed and used to manage stockpiles across different levels and regions [41].

Limitations
The available assessment indicators are relatively narrower in comparison with those such as the Capability
Table 5 Evaluation of coping capability and recovery stage by levels and regions in 2012

| Level/region | n   | Average  | Points 95% CI | Provincial  | Points 95% CI | Municipal  | Points 95% CI | County  | Points 95% CI | East  | Points 95% CI | Central  | Points 95% CI | West  | Points 95% CI |
|--------------|-----|----------|---------------|------------|---------------|------------|---------------|---------|---------------|-------|---------------|----------|---------------|-------|---------------|
|              |     |          | Emergency confirmation | Response preparedness | On-site response | Implementation of control measures | Archiving | Analyzing | Concluding |
| Average      | 271 | 9.61     | 9.52–9.69     | 9.25       | 9.15–9.34     | 9.21       | 9.12–9.30     | 9.17    | 9.08–9.26     | 8.33  | 8.15–8.52     | 5.83    | 5.59–6.07     | 5.69  | 5.45–5.95     |
| Provincial   | 25  | 9.73     | 9.53–9.88     | 9.75       | 9.66–9.83     | 9.77       | 9.71–9.83     | 9.65    | 9.54–9.76     | 7.98  | 7.46–8.48     | 5.85    | 5.18–6.49     | 6.17  | 5.57–6.80     |
| Municipal    | 102 | 9.85     | 9.78–9.92     | 9.44       | 9.33–9.53     | 9.43       | 9.35–9.51     | 9.46    | 9.38–9.54     | 8.54  | 8.27–8.81     | 5.37    | 4.99–5.76     | 5.34  | 4.96–5.70     |
| County       | 114 | 9.27     | 9.08–9.46     | 8.82       | 8.63–9.02     | 8.73       | 8.54–8.93     | 8.63    | 8.44–8.83     | 8.22  | 7.90–8.53     | 6.40    | 6.00–8.60     | 5.93  | 5.57–6.31     |
| East         | 70  | 9.65     | 9.50–9.80     | 9.20       | 9.01–9.36     | 9.24       | 9.07–9.40     | 9.03    | 8.84–9.20     | 7.80  | 7.41–8.18     | 5.74    | 5.29–6.20     | 5.45  | 5.00–5.94     |
| Central      | 81  | 9.54     | 9.36–9.71     | 9.23       | 9.05–9.39     | 8.98       | 8.79–9.14     | 9.09    | 8.90–9.26     | 8.73  | 8.43–9.03     | 5.44    | 5.00–5.89     | 5.38  | 4.96–5.83     |
| West         | 120 | 9.63     | 9.51–9.74     | 9.31       | 9.17–9.43     | 9.38       | 9.26–9.49     | 9.34    | 9.22–9.46     | 8.39  | 8.07–8.68     | 6.22    | 5.81–6.60     | 6.11  | 5.73–6.46     |

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Nearly half the indicators were binary (“yes” or “no”), so the quality of policy implementation and accountability could not be judged.

Although logic judgments and audit procedures were conducted, recall bias may still exist. Despite these limitations, the main contribution of this paper is the findings based on the data from two rounds of national field surveys conducted in 2002 to 2012 in China. We believe that this contribution is theoretically and practically relevant because the lessons China’s government learned from the 2003 SARS outbreak provide an emergency response framework that can be employed by developing countries.

Conclusions
Since the 2003 SARS outbreak, China has built an effective PHEMS and achieved comprehensive progress and improvements at preparation, readiness, response, and recovery. Nevertheless, lacks of conceptual crisis management and preventive governance, disparities across regions and levels, and insufficient application of new technologies remain. Future priorities should be to develop the recovery stage, establish a closed-feedback loop between recovery and preparation stages, and strengthen capability-building CDCs in Western areas through increasing governmental funding and improving the quality of response personnel. The guarantees of leadership, regulations, and resources provide useful references for other developing countries.

Abbreviations
CDC: Center for Disease Prevention and Control; MOH: Ministry of Health; PHEMS: Public Health Emergency Management System; SARS: severe acute respiratory syndrome; WHA: World Health Assembly; WHO: World Health Organization

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Availability of data and materials
This survey was administered in the collaboration with National Health Commission of the People’s Republic of China (the former Ministry of Health), and the data ownership belongs to former MOH. We just got the admission of certain data fields to analyze, so we are sorry that we cannot provide basic data.

Authors’ contributions
MS participated in study design and conception, data acquisition, data analysis, manuscript drafting, and funding acquisition. NX participated in data analysis and manuscript drafting. CL, YW and LL participated in data acquisition. DW participated in data analysis. JZ participated in discussion and manuscript revision. MY, YZ, HW, PS, ZC and JY participated in the design and conceptualization of the study, acquisition of data, and data interpretation. JW, YL, QL, XW, ZB, MF, and LF participated in the interpretation and acquisition of data. MH participated in the design and conceptualization of study, acquisition of data, revising of the manuscript, acquisition of funding, and supervision. All authors read and approved the final manuscript.

Ethics approval and consent to participate
The study was approved by the Medical Research Ethics Committee at the School of Public Health of Fudan University. The access to the survey data used in this study was approved by the National Health Commission of the People’s Republic of China (the former Ministry of Health). This study didn’t involve human participants and there was no data collected from humans or animals. Consent to participate for patients were not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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