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## Original Research

# Cross-sectional survey on public health informatics workforce in China: issues, developments and the future



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## ABSTRACT

**Objective:** To explore the current situation and issues related to the development of the public health informatics (PHI) workforce in provincial and prefectural centers for disease control and prevention (CDCs) in China, and to describe the corresponding strategies to address these issues for the future.

**Study design:** National cross-sectional study.

**Methods:** One thousand two hundred and eighty-one respondents were selected at random from provincial and prefectural CDCs. The survey used a self-administered, structured questionnaire with an online data collection tool that integrated data quality control and user management. The questionnaire was divided into seven main categories. Score percentage of satisfaction and proportion in each part were calculated. Descriptive statistics were used to analyse the data, stratifying by country region, CDC level, job role and educational level.

**Results:** One hundred and sixty staff from provincial CDCs and 1121 staff from prefectural CDCs were selected. Only 7.4% (33/445) of prefectural CDCs were not involved in this survey, due to lack of PHI practitioners. CDC staff in the eastern region were predominantly aged 30–39 years (39.5%), which was much younger compared with the other regions ( $P = 0.0012$ ). Only 34 respondents (2.7%) had academic majors in both health and information technology. More staff had Master's degrees and a higher level of education (18.7%) in the eastern region compared with the other regions ( $P < 0.0001$ ). Staff in the eastern region in high-level positions and with a higher level of education were more knowledgeable about PHI strategy. Prefectural CDC staff were more satisfied with their work and training than provincial CDC staff. In the eastern region, 34.9% of staff were hired through competitive recruitment, and 57.8% of staff had received a job description with detailed information about their responsibilities, which was higher than in the other regions. Staff in the western region were more likely to leave if a better job became available (37.7%) compared with staff in the other regions ( $P = 0.0116$ ).

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*Conclusion:* This study found regional disparities in PHI workforce development, possibly related to disparities in overall regional development. Findings showed a severe shortage of staff with a background in PHI, and occupational development paths were clearly lacking. Based on this study of current workforce issues, a comprehensive strategy for PHI workforce development in China has been described.

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## Introduction

Public health informatics (PHI) was defined in 1995 as systematic application of information and computer science and technology to public health practice, research and learning.<sup>1,2</sup> The knowledge domain of PHI includes public health, informatics, engineering, social science, management, etc. This concept is better known in the USA, where a number of PHI training programmes have been established, such as the two-year public health informatics fellowship programme at the US Centers for Disease Control and Prevention (CDC),<sup>3</sup> and academic training programmes at Johns Hopkins University, University of Utah and University of Washington.<sup>4</sup>

However, barriers to the widespread application of PHI exist worldwide, including a lack of public health practitioners who have received formal training in PHI.<sup>5</sup> A survey using information from 74 universities and colleges across Canada showed that of the 74 institutions searched, only eight institutions offered full health informatics-related programmes, and of these eight programmes, only one had content relevant to PHI.<sup>6</sup> In Australia, there was no clear definition and categorization of PHI, and PHI first appeared in the Australia's Health Informatics Conference in 2012.<sup>2</sup>

The technology necessary for effective, innovative application of health information to public health practice is available today at very reasonable cost.<sup>7</sup> Following the outbreak of severe acute respiratory syndrome in China in 2003, there were widespread applications for information technology (IT) in public health, such as the national web-based notifiable infectious disease surveillance system, emergency event reporting system, immunization management system, risk factor surveillance system, death and birth registry system, etc. Data centres with requisite hardware and software were also constructed at various CDC levels in China (four levels of CDCs in China cover most public health work, including one national CDC, 32 provincial CDCs, 354 prefectural CDCs and 3096 county CDCs). IT applications to support health reform and accelerate healthcare development will play an important role in the Twelfth five-year Plan period.

PHI is an interdisciplinary field and is relatively new in China, although some IT projects have been implemented in the public health domain. China is in great need of qualified public health informaticians to systematically perform increasingly complex tasks.<sup>8</sup> As the first national survey on PHI workforce development in China, this paper focuses on the current situation and development of a PHI workforce in CDCs in China based on a national cross-sectional study, with the aim of identifying issues and gaps, and describing a

strategic direction for sustainable PHI workforce development in the future. The strategy for selection of respondents in the survey was based on a 2010 survey that covered nearly all CDCs in China, and investigated PHI workforce number, IT investments, network, hardware and systems development.<sup>9</sup> The 2010 survey showed an average of 10 informaticians in each provincial CDC, five in each prefectural CDC and four in each county CDC. Considering the lack of PHI workforce in most county CDCs, the 2012 survey was restricted to the informaticians at provincial CDCs, prefectural CDCs and county CDCs in municipalities directly under the Central Government.

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## Methods

### Study design

The national PHI workforce online survey in CDCs in China was launched in July 2012 and completed in December 2012. Respondents were defined as CDC staff whose work was related to PHI, including statistics, information science, computer science, engineering and IT project management. They worked in information centres in CDCs, which were departments responsible for IT technical support. The supportive scope of the information centres covered all aspects of public health, including communicable diseases, non-communicable diseases, environmental hygiene, etc. The routine work of the respondents involved system design, system requirements analysis, data analysis, data mining, data sharing, and network and system maintenance. In total, 1281 respondents were selected at random (five per provincial CDC and three per prefectural CDC) based on the 2010 survey results (approximately 1800 PHI staff at provincial and prefectural CDCs). These respondents had been involved in work related to PHI in the CDCs for more than one year. The Director of the Information Centre in each CDC was responsible for the random selection of respondents. The survey was conducted through a self-administered, structured questionnaire, which was validated by human resources consultants and health professionals. It consisted of seven parts including: (1) demographic information (i.e. age, sex, education); (2) knowledge of PHI development in CDCs, including the goal of PHI development and the strategic plans for PHI in CDCs; (3) self-assessment of personal work (i.e. satisfaction with workload, fitness, salary, job role, clear job description) and CDC support (i.e. clear competency-based certification and workforce promotion pathways); (4) personnel training on PHI, including

satisfaction with training content and frequency; (5) recruitment and employment of new staff; (6) work evaluation from CDC; and (7) outflow of the workforce. Online training regarding how to complete the survey was conducted before the survey. An online data collection tool ['Epidemiological Dynamic Data Collection' (EDDC)] was used.<sup>10,11</sup> This was developed by the Chinese CDC with support from the World Health Organization (WHO). It was formerly known as Web 'Epidata'<sup>12</sup> as it integrated most functions of Epidata and was web based, more powerful and flexible. Data quality was controlled by the EDDC system. All the logical error checks in the questionnaire were integrated into the system. Each CDC had its own username and password for the system. The system recorded each user's name and reporting date automatically after the user submitted the data. The authors followed-up each CDC to ensure an adequate response.

### Statistical analysis

Parts 2–4 in the questionnaire contained cognitive and satisfaction questions, and five-point Likert scales were used to indicate the degree of agreement or disagreement with statements.<sup>13</sup> The average score percentage for each part represented a comprehensive evaluation for each aspect, which was calculated as actual score sum divided by maximum score for all questions in each part, multiplied by 100%. For Parts 5–7, the options were unordered categories and proportion was used as the analysis indicator.

The data were downloaded directly from the EDDC system and analysed using SAS Version 9.2. Kruskal–Wallis H test (a non-parametric test) was used to test for significance of the differences in score percentages, as the scores were not normally distributed.<sup>14</sup> Multiple comparisons of the score percentages were implemented using Bonferroni's correction method,<sup>15</sup> which took type I error into account. Pearson's Chi-squared test was used to compare proportions.  $P < 0.05$  was considered to indicate significance.

## Results

Thirty-two provincial CDCs (including Production and Construction Corps of Xinjiang) and 445 prefectural CDCs were divided into three regions (east, central and west) based on the basic coding manual of the Chinese Disease Control and Prevention Information System (Table 1). Only 7.4% (33/445) of prefectural CDCs were not involved in this survey. The main reason for non-participation was the lack of an information centre, which made it difficult to identify PHI practitioners. One hundred and sixty staff from provincial CDCs and 1121 staff from prefectural CDCs were contacted and completed the online questionnaire.

Table 2 presents the demographic characteristics of the respondents by region. There were significant differences in age, educational level and academic major between the regions. A large proportion of staff in the eastern region staff (39.5%) were aged 30–39 years, which was much younger compared with the other regions ( $P = 0.0012$ ). Most staff with a Master's degree or a higher level of education were in the eastern region (18.7%) ( $P < 0.0001$ ). There were more staff with

**Table 1 – Provinces in eastern, central and western regions of China.**

Regions	Provinces
East	Beijing, Tianjin, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan
Central	Hebei, Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan
West	Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang, Production and Construction Corps of Xinjiang

IT-related academic majors in the eastern region (31.8%) compared with the other regions ( $P < 0.0001$ ). Only 34 respondents (2.7%) had academic majors in both health and IT.

Table 3 shows the respondents' score percentages in Parts 2–4. In Part 2, there were significant differences between regions, job roles and educational levels of the respondents. In the eastern region, staff in leadership positions and with a higher level of education were more knowledgeable about PHI strategy compared with other staff. In Parts 3 and 4, in the eastern region, staff in leadership positions and with a higher level of education were more inclined to report satisfaction with their personal work and training compared with other staff. Prefectural CDC staff reported a higher level of satisfaction with their work and training than staff in provincial CDCs. Overall, comparing Parts 2–4 of the questionnaire, the average satisfaction score was lowest for training (51.6%) followed by personal work (57.4%).

Parts 5–7 of the questionnaire focused on recruitment, job role, evaluation standard and outflow of the workforce. Table 4 presents the differences between the three regions. In the eastern region, 34.9% of staff were hired competitively, which was significantly higher compared with the other regions ( $P < 0.0001$ ). Regarding description of their current job role, 57.8% of respondents reported they had detailed information about their responsibilities, particularly in the eastern region (62.1%,  $P = 0.004$ ). When asked about the type of evaluation standard that CDC used to assess their work, most respondents reported that evaluations were based on quantity (70.7%) and quality (75.6%) of work. In addition, CDCs in the eastern region were most satisfied with services (45.1%,  $P = 0.0005$ ), and CDCs in the western region were most satisfied with economic benefit (11.4%,  $P = 0.013$ ). Regarding outflow of the workforce, staff in CDCs in the western region were most likely to leave if a better job became available (37.7%,  $P = 0.0116$ ).

## Discussion

### Issues and countermeasures

The main goals of this study were to explore the development of the PHI workforce in China, to identify potential

**Table 2 – Comparison of demographic information by region.**

	East n (%)	Central n (%)	West n (%)	Total n (%)
Age (years) <sup>a</sup>				
<30	47 (12.1)	37 (9.9)	71 (13.7)	155 (12.1)
30–39	154 (39.5)	109 (29.1)	143 (27.7)	406 (31.7)
40–49	143 (36.7)	157 (42.0)	218 (42.2)	518 (40.4)
≥50	46 (11.8)	71 (19.0)	85 (16.4)	202 (15.8)
Sex				
Male	285 (73.1)	283 (75.7)	359 (69.4)	927 (72.4)
Female	105 (26.9)	91 (24.3)	158 (30.6)	354 (27.6)
Educational level <sup>a</sup>				
Below bachelor	47 (12.1)	76 (20.3)	147 (28.4)	270 (21.1)
Bachelor	270 (69.2)	252 (67.4)	330 (63.8)	852 (66.5)
Master or higher	73 (18.7)	46 (12.3)	40 (7.7)	159 (12.4)
Major (multiple choices) <sup>a</sup>				
Computer/Engineer/Informatics	124 (31.8)	87 (23.3)	78 (15.1)	289 (22.6)
Medicine/Public Health/Biomedicine	240 (61.5)	262 (70.1)	395 (76.4)	897 (70)
Others	50 (12.8)	48 (12.8)	70 (13.5)	168 (13.1)
Professional title				
High title	156 (40.0)	164 (43.9)	183 (35.4)	503 (39.3)
Middle title	128 (32.8)	116 (31.0)	170 (32.9)	414 (32.3)
Basic title	106 (27.2)	94 (25.1)	164 (31.7)	364 (28.4)
Job role				
Leader <sup>b</sup>	218 (55.9)	235 (62.8)	314 (60.7)	767 (59.9)
Other staff	172 (44.1)	139 (37.2)	203 (39.3)	514 (40.1)

$\chi^2$  test, P-values reported for regional differences in each category.

<sup>a</sup> P < 0.05.

<sup>b</sup> Public health informatics management role at a centre for disease control and prevention, including director, deputy director or branch (office) chief.

opportunities for improvement, and to describe a strategic plan for workforce development for the future. This study found that human resources for PHI in provincial and prefectural CDCs in China had already reached a certain level. The majority (92.4%) of respondents had worked in CDCs for more than three years and accumulated some experience on PHI. The PHI strategy was established in the CDCs, and most staff were knowledgeable about it.

However, in this study, the authors also found several issues related to the PHI workforce. Firstly, there was disparity in PHI development among regions. Staff in the eastern region were younger, had a higher level of education, were more knowledgeable about the PHI strategy, and were more satisfied with their work and training. CDCs in the eastern region had better systems in place for recruitment and attraction of the workforce. This may be attributed to

**Table 3 – Comparison of scores (%) in each questionnaire part.**

	Score (%) in Part 2	P-value	Score (%) in Part 3	P-value	Score (%) in Part 4	P-value
Region						
East	70.13	<0.0001	59.69	<b>0.0008</b>	55.19	<b>0.0206</b>
Central	63.68		55.75		47.59	
West	61.80		57.21		51.79	
Level of CDC						
Provincial	68.18	0.1234	52.45	<0.0001	41.25	<0.0001
Prefectural	64.41		58.26		53.08	
Job role						
Leader	68.61	<0.0001	60.68	<0.0001	55.28	<0.0001
Other staff	59.32		52.85		46.11	
Educational level						
Below bachelor	58.73	<0.0001	53.84	<0.0001	46.20	<b>0.0043</b>
Bachelor	65.88		58.25		52.63	
Master or higher	69.97		60.02		55.27	
Average, score (%)	64.88		57.4		51.60	

CDC, centre for disease control and prevention.

Part 2 was on knowledge of informatics development in the CDC, Part 3 was on self-assessment of personal work, and Part 4 was on self-assessment of personnel training.

Kruskal–Wallis H test for the total differences within regions, CDC levels, job roles and educational levels for each questionnaire part. P-values in bold were statistically significant (P < 0.05).

**Table 4 – Staff opinions about recruitment, job role, centre for disease control and prevention (CDC) evaluation and workforce outflow.**

	East n (%)	Central n (%)	West n (%)	Total n (%)	P-value
Methods of recruitment					
Compete	136 (34.9)	78 (20.9)	99 (19.2)	313 (24.4)	<b>&lt;0.0001</b>
Talent introduction	20 (5.1)	25 (6.7)	26 (5)	71 (5.5)	0.5169
Employment agency introduction	0 (0)	0 (0)	4 (0.8)	4 (0.3)	<b>0.0420</b>
Guarantee job assignment	167 (42.8)	190 (50.8)	229 (44.3)	586 (45.7)	0.0597
Other	52 (13.3)	61 (16.3)	115 (22.2)	228 (17.8)	<b>0.0016</b>
Description of current job role					
Yes, with detailed information about responsibilities	242 (62.1)	190 (50.8)	308 (59.6)	740 (57.8)	<b>0.0040</b>
Yes, with name and content	91 (23.3)	95 (25.4)	111 (21.5)	297 (23.2)	0.3887
No, only brief introduction	33 (8.5)	57 (15.2)	53 (10.3)	143 (11.2)	<b>0.0083</b>
No, completely depend on myself	24 (6.2)	32 (8.6)	45 (8.7)	101 (7.9)	0.3137
Evaluation standard from CDC (multiple choices)					
Quantity of work	291 (74.6)	264 (70.6)	351 (67.9)	906 (70.7)	0.0881
Quality of work	299 (76.7)	280 (74.9)	389 (75.2)	968 (75.6)	0.8251
Satisfaction with services	176 (45.1)	120 (32.1)	219 (42.4)	515 (40.2)	<b>0.0005</b>
Attendance	165 (42.3)	162 (43.3)	247 (47.8)	574 (44.8)	0.2056
Economic benefit	24 (6.2)	28 (7.5)	59 (11.4)	111 (8.7)	<b>0.0130</b>
Research achievement	69 (17.7)	54 (14.4)	67 (13)	190 (14.8)	0.1349
Budget performance	43 (11)	23 (6.1)	48 (9.3)	114 (8.9)	0.0562
Other	10 (2.6)	15 (4)	25 (4.8)	50 (3.9)	0.2150
Would you resign if a better job became available?					
Yes	112 (28.7)	117 (31.3)	195 (37.7)	424 (33.1)	<b>0.0116</b>
No	193 (49.5)	158 (42.3)	209 (40.4)	560 (43.7)	<b>0.0194</b>
Didn't answer	85 (21.8)	99 (26.5)	113 (21.9)	297 (23.2)	0.2017

$\chi^2$  test, P-values in bold were statistically significant ( $P < 0.05$ ).

disparities in regional development, such as the level of gross domestic product, local government investment, and local policy on talent development. Secondly, there was a shortage of staff with a background in PHI able to address the complexity of PHI tasks. Thirdly, the score for satisfaction with training was extremely low. Coverage, frequency and content of training need to be improved. Fourthly, there is a need for a clearly articulated occupational development path for workforce development, including education, definition of job role, promotion, assessment standard and in-job training. Components of the occupational development path should be closely linked. In this study, only 39.3% of respondents reported they had a clear occupational

development path. Finally, the score for job satisfaction showed significant differences between levels of CDC, job role and educational level, which indicates that the concerns of provincial CDC staff, general staff and staff in lower positions need to be addressed.

These issues should be addressed using a hierarchical model. Organization and individual are the main factors that influence these issues. As such, all the indicators based on the need for organization development and skilled workforce development were extracted. In the PHI domain, skilled workforce development can be divided into national strategic support and local skills support. The conceptual framework for developing the PHI workforce was described considering



**Fig. 1 – Framework for development of public health informatics (PHI) workforce.**

disparities in regional development and diverse levels of CDCs (Fig. 1). The following three strategies will promote development of the current workforce.

First, for organization development, policy and funding support must target the central and western regions in order to attract and retain more talented personnel. Optimizing organizational structure can help provide top priority to the PHI. Communication and collaboration between the eastern, central and western regions and international organizations may lead to common progress. Culture building, such as leisure-time activity organization, will play an important role in work satisfaction.

Second, national or regional strategic support must be more macro-level, comprehensive and instructional, and include policy making, standard making, framework, method or technique innovation and improvement, project evaluation, work inspection and monitoring, and overall training.

Third, local skills development must be more specific and targeted. The skills must be requirement driven instead of pursuing the most advanced techniques. PHI activity could be community based and technique based.

### Political feasibility

Based on the findings from this study, the authors suggested three main strategies for achieving PHI workforce development objectives in China. The short-term strategy is to establish Chinese competency schema of PHI and standardize the objective, competency, education course and job descriptions of PHI according to the current situation and framework in developed countries; promote collaborative relationships with international PHI organizations; and encourage the PHI workforce to take an active part in international training programmes. The medium-term strategy is to establish the PHI education, training and examination schema with support from the Ministry of Industry and Information Technology and the Ministry of Education; keep close contact with the government and university, and improve the system of occupational training; and increase investment in PHI organization improvement and workforce training. The long-term strategy is to establish the PHI labour code and PHI occupational development paths; explore the evaluation system of the PHI workforce; and solve the problems in PHI workforce development completely.

### Author statements

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### Competing interests

None declared.

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