Open Forum Infectious Diseases

MAJOR ARTICLE

Social Media Survey and Web Posting Assessment of the COVID-19 Response in China: Health Worker Attitudes Toward Preparedness and Personal Protective Equipment Shortages

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Background. Understanding health worker awareness, attitudes, and self-confidence in the workplace can inform local and global responses toward emerging infectious threats, like the coronavirus disease 2019 (COVID-19) pandemic. Availability of accessible personal protective equipment (PPE) is vital to effective care and prevention.

Methods. We conducted a cross-sectional survey from February 24 to 28, 2020, to assess COVID-19 preparedness among health workers. In addition, we assessed trends from search engine web crawling and text-mining data trending over the Sina Weibo platform from January 1 to March 3, 2020. Data were abstracted on Chinese outbreak preparedness.

Results. In the survey, we engaged 6350 persons, of whom 1065 agreed to participate, and after an eligibility logic check, 1052 participated (16.6%). We accessed 412 internet posts as to PPE availability. Health workers who were satisfied with current preparedness to address COVID-19 were more likely to be female, to obtain knowledge about the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) outbreak from government organizations, and to consider their hospital prepared for outbreak management. Health workers with more confidence in their abilities to respond were those with more faith in their institution's response capacities. Elements of readiness included having airborne infection isolation rooms, visitor control procedures, and training in precautions and PPE use. Both survey and web post assessments suggested that health workers in need were unable to reliably obtain PPE.

Conclusions. Health workers' self-confidence depends on perceived institutional readiness. Failure to maintain available PPE inventory for emerging infectious diseases preparedness suggests a failure to learn key lessons from the 2003–2004 SARS outbreak in China.

Keywords. awareness; confidence; COVID-19; health worker; preparedness and response.

According to coronavirus disease (COVID-2019) situation reports from the World Health Organization (WHO), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections had been reported by 213 countries, territories, or international conveyances (ships) by August 8, 2020 [1]. China has been classified a level 5 country for community viral transmission, the highest level of concern [2], based on clusters of cases. The WHO has urged nations to prepare for the threat of autochthonous transmission, noting that emerging cases from secondary transmission now typically lack a direct link to the original Chinese epicenter. The US Centers for Disease Control and Prevention (CDC) defines a pandemic as a global disease outbreak (ie, multicontinent) in its all-hazards preparedness guide [3]. A vital component of addressing both local and pandemic infectious threats is health professional preparedness.

In the WHO influenza pandemic plan in 1999, the WHO urged the global community for plans to address "infectious diseases: global alert, global response" [4]. This plan was eerily prescient of the SARS pandemic just 4 years later. The roles and responsibilities of the WHO and national authorities in preparing for and responding to an influenza pandemic are identical to what would be needed for other respiratory pandemic threats.

Health workers are critical for building societal confidence during epidemic outbreaks. They cannot function effectively if they lack the personal protective equipment (PPE) essential to ensuring continuity of health care services during a public health emergency and to avoiding nosocomial acquisitions [5]. PPE supply chain lessons from recent outbreaks, such as the epidemic of the 2009 H1N1, 2013–2014 H7N9, and 2014

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Ebola outbreaks highlight the need for rational, equitable, and transparent stockpiling and allocation during epidemic responses [6, 7].

As of April 4, 2020, 60 Chinese health care workers have died, of whom 22 (36.7%) were confirmed dead of COVID-19, according to reports by China Central Television. At least 3387 medical staff from 476 medical institutions across the country were infected with SARS-COV-2, including 2055 confirmed cases, 1070 clinically diagnosed cases, and 157 suspected cases. In Hubei Province alone, 3062 infected cases (>90% of the national total) in health care workers were reported by February 24, 2020 [7]. (No further update was released officially as hospital burdens were eased after a large national-wide medical task force was dispatched to Hubei province for assistance.)

We sought to study health worker self-perception of preparedness and PPE availability in 2020, over 2 decades after the WHO call for pandemic influenza readiness.

METHODS

Design and Setting

Our mixed-methods study was a 2-part effort consisting of (1) an online cross-sectional survey using an online electronic questionnaire and (2) a mining of web text via data crawling of PPE-related postings (Figure 1). Data crawling is a technique for data extraction from the internet using a crawling agent (automated script) that helps gather publicly available data in very large quantities. Our survey was based on the WHO and CDC preparedness checklists, and we targeted licenced health

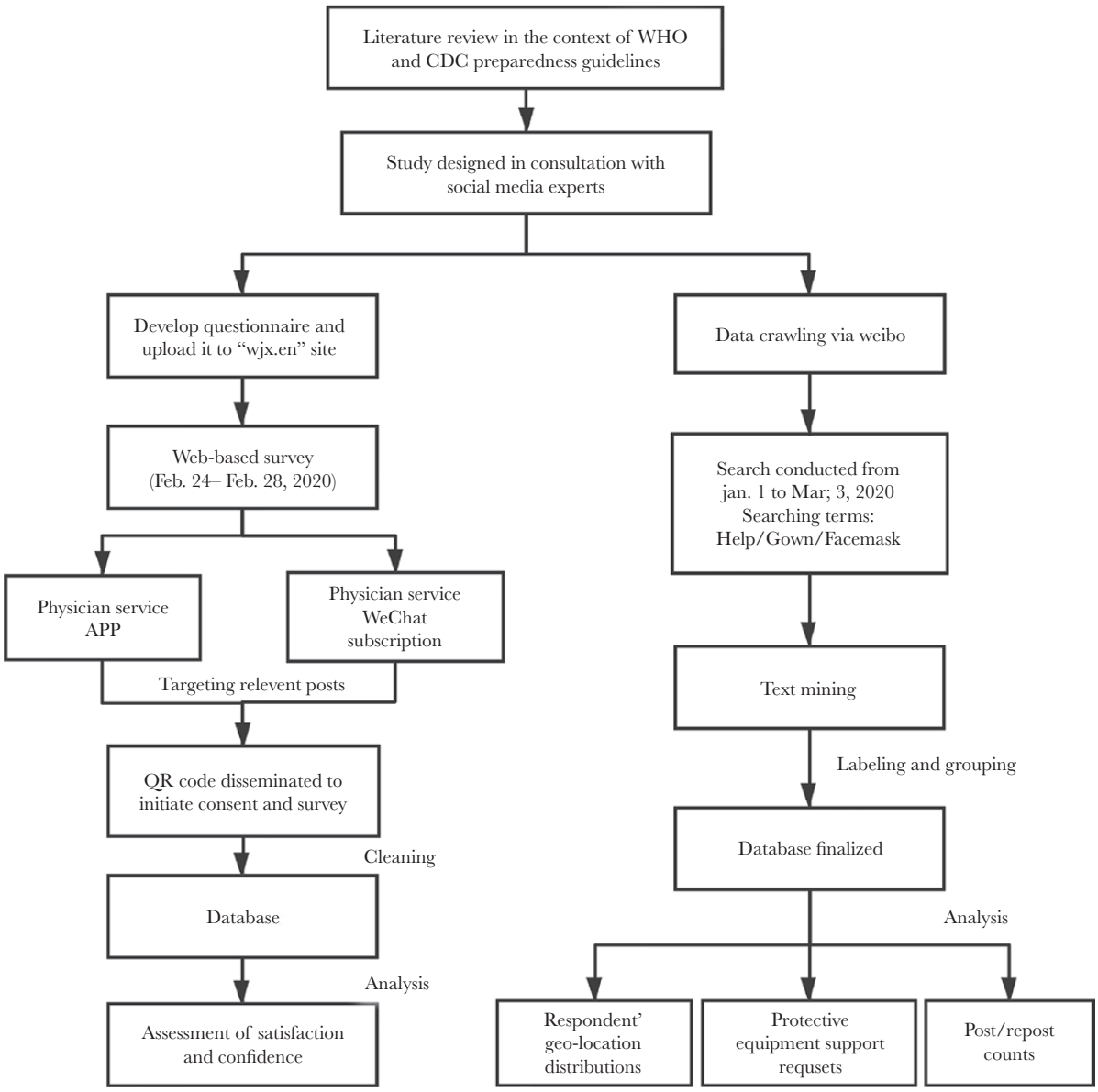

Figure 1. Study design flowchart. Abbreviations: CDC, Centers for Disease Control and Prevention; QR code, Quick Response code; WHO, World Health Organization.

workers, evaluating awareness of and confidence in COVID-19 preparedness and response at their institutions. We also reviewed policy changes on provision of PPE in China related to the 2019–2020 SARS-CoV-2 outbreak.

Participants

Our survey targeted health workers based in hospitals, including physicians, nurses, and others. Eligible participants were licensed health workers in practice; given our Hubei province focus, this included workers at the front line of care provision in the midst of the COVID-19 crisis. While we did not indicate exclusion criteria in the recruitment poster (Supplementary Figure 1), we specified our research aims regarding self-perception of health worker preparedness. Online consent was obtained for participation.

Recruitment Procedures

Participants were recruited using 2 methods. The first was an online advertisement on a health worker–themed application (App) called "Physician Service App" (医师服务App; Yisheng Yishi Medical [Beijing] Technology Co., Ltd). This App provides health workers with online training, self-assessments based on mobile internet technology, and scientific research tools and content via a partnership with the Chinese Doctors Association, assisting them with regular assessments of >2.4 million physicians in 16 provinces in China. As a result, the app is widely promoted and recognized among health workers, facilitating our use of the app for the survey.

The second means of recruitment was engagement via WeChat "moments sharing." WeChat is a comprehensive package of online services, equivalent to a combination of apps such as Facebook, WhatsApp, and PayPal. Eligible recruited persons providing consent were given a self-administered structured questionnaire online using wjx (https://www.wjx.cn/). wjx is similar to SurveyMonkey and is more popular and accessible in China. We developed a poster with a Quick Response (QR) code to link people to the questionnaire (Supplementary Figure 1). Both the Physician Service App and WeChat moments sharing methods promoted the poster and encouraged interested health workers to identify the QR code and enter the online survey system. The first page of the questionnaire assessed eligibility and obtained informed consent for those who were eligible. No incentive was provided for survey participation.

Variables

We studied 3 main outcome indicators using a 5- or 3-point Likert scale: (1) satisfaction with preparedness of protective equipment (PPE) for addressing the outbreak of COVID-19 from very dissatisfied to very satisfied (1–5); (2) current sense of confidence in coping with COVID-19 cases from very low to very high (1–5); and (3) sense of confidence in institutional capacity for addressing emerging infectious diseases (EIDs) in the future (1–3). These predictors and covariates were developed according to the WHO and US CDC preparedness checklists to measure awareness, PPE and diagnosis knowledge, and confidence in future responses addressing similar EIDs.

Data Analysis

Text mining of the Weibo announcement searched (in Chinese) for "(help OR support OR donate) AND PPE." Weibo is a Twitter-like social media platform in China. People share social, cultural, and historical insights or comments on trending topics via the platform. We crawled text data or scripts of the video of needed PPE including "求助" (help) or "防护服" (gown) or "口罩" (facemask) from https://weibo.com/ from January 1, 2020, through March 3, 2020, using Python 3.8.2. After manually verifying and cleaning the raw data, we removed repeated information and obtained 412 announcements calling for help throughout China from the original 552.

Data Analysis of the Online Survey

The survey data were exported into Microsoft Excel and then manually labeled with the level of the capability of the hospital according to the 3-tier category in China. Through the dynamic IP address and the name of the local hospital, we identified the geo-location of the participants and generated 2 variables of the location as "city" and "province" for each participant. In the case of a conflict between IP address and hospital, we chose the affiliated hospital for location classification. Completed databases were analyzed after data cleaning using the Statistical Analysis System (version 9.4; SAS Institute Inc, Cary, NC, USA). We used univariate and multivariable logistic regression analysis to identify the association between a respondent's current confidence in coping with COVID-19 suspected/confirmed cases and his/her sociodemographic characteristics. Crude and adjusted odds ratios (cORs and aORs) with 95% confidence intervals were calculated for the association of the covariates with the outcome (self-confidence). The variables with a P value of ≤.05 in univariate analysis were entered into the multivariable backward regression models, and only variables with 2-sided P value of ≤.05 were considered statistically significant in the final model.

Visualization was conducted using the R software (R Foundation for Statistical Computing, Vienna, Austria; http://www.R-project.org/) ggplot package in China Map and Microsoft Excel for the locations and cities of respondents who were reaching out for help accessing PPE.

Patient Consent Statement

The study was approved by the Capital Medical University Ethics Review Board (2020SY004). The study protocol, contents, and procedure were explained before survey inception. Online consent was obtained for participation. Nonidentifiable data from the app were collected or analyzed per the study protocol.

RESULTS

The web-based questionnaire was uploaded on February 24, 2020, and taken offline on February 28, 2020 (3.5 days), after enrollment goals were exceeded. The study approached 6350 persons, and 1065 (16.8%) responded to the survey. Among them, 623 of 5653 were app users (11.0%); 444 of 697 (63.7%) WeChat users shared the link. After eligibility assessment, 1052 respondents (16.6%) were analyzed from 146 cities in 24 provinces in China (Figure 2), with similar numbers of men (52.4%) and women (47.6%) and with a median age (interquartile range) of 33 (25–45) years. Nearly one-third (31.7%; n = 333) of the 1052 participants were from the epicenter in Hubei Province, most (n = 209) from Jingzhou city; 28.1% worked in secondary and 14.2% in tertiary hospitals (Supplementary Figure 2a). Participants came from 8 types of hospitals, including 25.4% from general hospitals (Supplementary Figure 2b). Doctors accounted for 75.8% of the respondents, nurses represented 17.3%, and others represented 6.9%. Fewer than half (48%) of participants were satisfied with the protective equipment in the hospital to cope with the COVID-19 epidemic, and 6.4% of respondents were very dissatisfied. Nearly three-quarters (73%) of health workers expressed self-confidence in coping with persons under investigation (PUIs) or known patients. About half (53%) of the participants expressed confidence in institutional preparedness and in the institution's ability to respond to EIDs in the future (Table 1).

There were 412 posts of PPE request announcements from our Weibo crawl during January 1 to March 3, 2020. For 386 posts, we were able to do manual city-labeling, narrowing the focus of the request for PPE and mapping respondents' locations (Figure 2).

Weibo posts calling for help or donations of PPE, including gowns, facemasks, and goggles, increased sharply from January 23 to January 25, 2020, and the number of cities that posted requests for urgent help for medical supplies online increased drastically and then leveled (Figure 3). Cumulatively, 412 posts (like Tweets) had 254 597 hits/counts, while 28 212 re-posts (re-tweets) incurred 300 597 942 counts. This interest level coincided with the timeline on which the government dispatched medical staff from military and civil medical hospitals, as well as centralized management of PPE and deliveries to epicenters throughout China, especially Wuhan. This social media interest spike was most dramatic in the 2-day period of January 31–February 1, 2020. After this, the number of posts that called for PPE donations decreased, as did the number of cities represented in these requests. The peak number of Weibo posts on PPE mainly appeared on January 24, January 25, January 31, and February 1, and then gradually showed

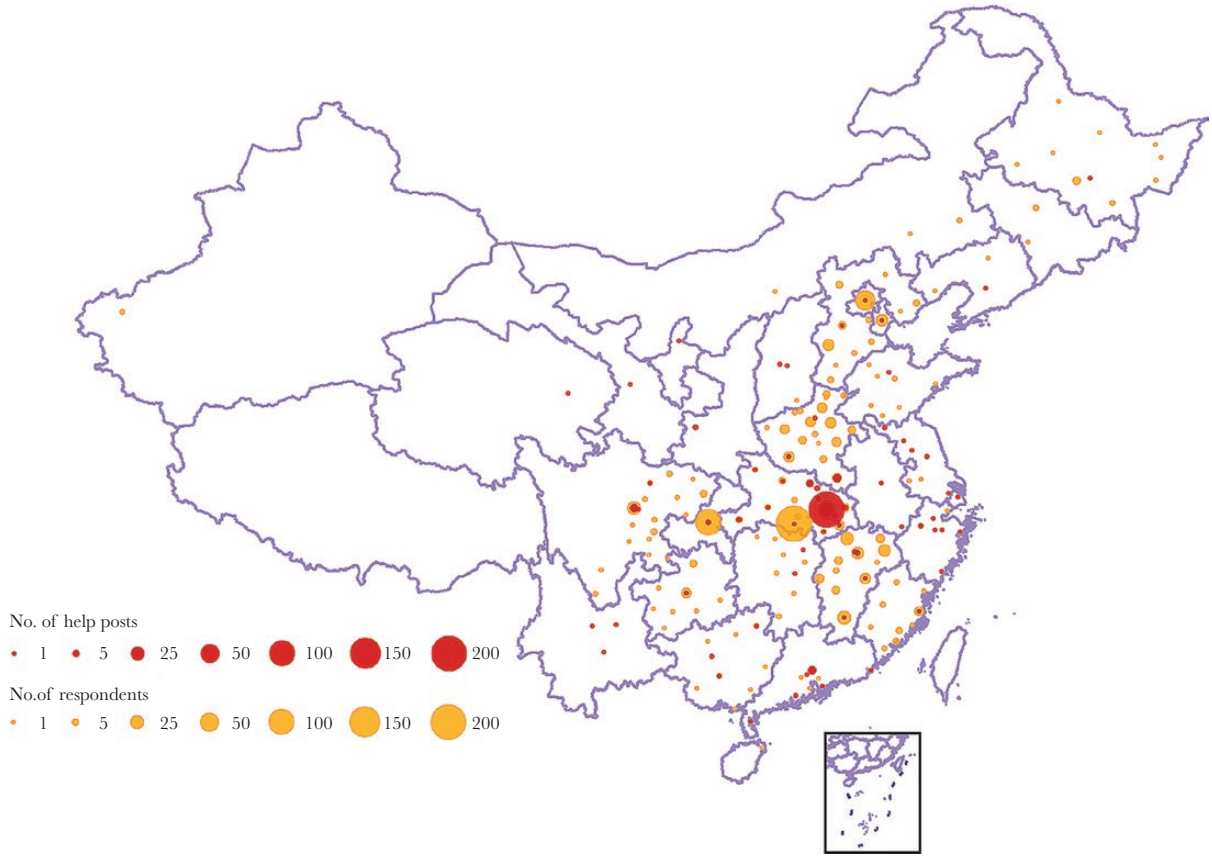

Figure 2. Help posts and respondents' geo-location distribution throughout the mainland of China.

Table 1. Sociodemographic Characteristics of the Web Survey Participants (n = 1052)

Factors	No.	%
Sex		
Male	551	52.4
Female	501	47.6
Age, y	33 (median)	25–45 (IQR)
Profession		
Doctor	797	75.8
Nurse	182	17.3
Others[a]	73	6.9
Department		
Outpatient	380	36.1
Respiratory	51	4.9
Emergency	45	4.3
Infectious diseases	21	2
Intensive care unit	18	1.7
Clinical testing laboratory	14	1.3
Others	523	49.7
Satisfaction with current preparedness of protective equipment in your hospital addressing the outbreak of COVID-19		
Very unsatisfied	67	6.4
Unsatisfied	159	15.1
Neutral	299	28.4
Satisfied	372	35.4
Very satisfied	133	12.6
Missing	22	2.1
Current confidence in dealing with suspected patient		
Not confident	41	3.9
Kind of unconfident	232	22.1
Confident	415	39.5
Kind of confident	202	19.2
Very confident	154	14.6
Missing	8	0.8
Confidence in preparedness and response of re/emerging infectious diseases in future by your institution		
High	558	53
Fair	368	35
Low	96	9.1
Missing	30	2.9

Abbreviations: COVID-19, coronavirus disease 2019; IQR, interquartile range.

[a]Other health care providers like disease control or health inspection specialists, as well a few pharmacists.

a downward trend. The number of Weibo reposts showed a rising wave with a peak on February 21, reflecting a peak of public attention.

After the lockdown of the city of Wuhan, policy guidance was gradually put into place. Health workers who were infected were seen in the early stages of the epidemic, correlating with the time of acute shortage of PPE. After centralized management and emergency response protocols and the action of PPE manufacturers to accelerate production and supply mobilization to the Hubei province epicenter, the number of health care workers being infected decreased significantly (Figure 3).

Supplementary Table 1 presents predictors of health workers' satisfaction with *current readiness of PPE* in their hospitals during the outbreak. Multivariable analysis suggested that health workers who were more satisfied with the readiness of the affiliated hospitals were more likely to be female (aOR, 1.30; 95% CI, 1.03–1.63), to obtain knowledge/information about the SARS-CoV-2 outbreak from government sources (aOR, 1.36; 95% CI, 1.03–1.81), to have airborne infection isolation rooms in their hospital (aOR, 2.15; 95% CI, 1.69–2.74), and to think their hospital is prepared for the outbreak (aOR, 4.28; 95% CI, 3.14–5.83).

Supplementary Table 2 presents predictors with a sense of confidence in treating patients and confidence in *current institutional readiness* during the outbreak. Those who tended to have higher current confidence to deal with suspected patients were more likely to be male health workers (aOR, 1.65; 95% CI, 1.29–2.11), to know how to use PPE (aOR, 2.52; 95% CI, 1.36–4.67), to know precautionary measures when performing aerosol-generating procedures (aOR, 1.44; 95% CI, 1.06–1.94), to understand reporting procedure of possible unprotected exposure to a COVID-19 patient or PUI (aOR, 2.25; 95% CI, 1.17–4.33), to consider themselves ready for management of the outbreak (OR, 2.16; 95% CI, 1.36–3.44), and to have a higher satisfaction with PPE (aOR, 1.90; 95% CI, 1.67–2.16). Other factors affecting the sense of self-confidence mainly relied on hospitals' readiness characteristics, as with availability of airborne infection isolation rooms in their hospital (aOR, 1.69; 95% CI, 1.30–2.20), having procedures in place for controlling visitors (aOR, 1.49; 95% CI, 1.01–2.18), and considering their hospital to be prepared for an outbreak (aOR, 1.59; 95% CI, 1.10–2.31).

Supplementary Table 3 describes current knowledge and confidence as related to the subjects' confidence in *future hospital preparedness*. Multivariable analysis shows that female health workers (aOR, 1.39; 95% CI, 1.04–1.86) had more confidence in the future preparedness of the hospital and in addressing emerging or remerging infectious diseases like COVID-19. Availability of airborne infection isolation rooms (aOR, 2.66; 95% CI, 1.95–3.63), perceived good hospital preparedness for the outbreak (aOR, 2.94; 95% CI, 2.03–4.28), high satisfaction with PPE (aOR, 1.76; 95% CI, 1.52–2.04), and current high confidence in handling patients or PUI (aOR, 1.74; 95% CI, 1.49–2.03) were associated with more confidence in future hospital preparedness.

We received feedback from 292 respondents (about one-third of participants) on the 1 *open-ended question* soliciting suggestions for how hospitals could better respond. Six categories of response were evident. Health workers suggested strengthening of training and monitoring of the specific donning and doffing processes of the gowns per the precaution standard (63%), ensuring an adequate supply of protective equipment (12%), strengthening hospital administrative management (11%), offering reasonable triage management for patients (7%), exercising self-discipline in order to increase immunity (5%), and

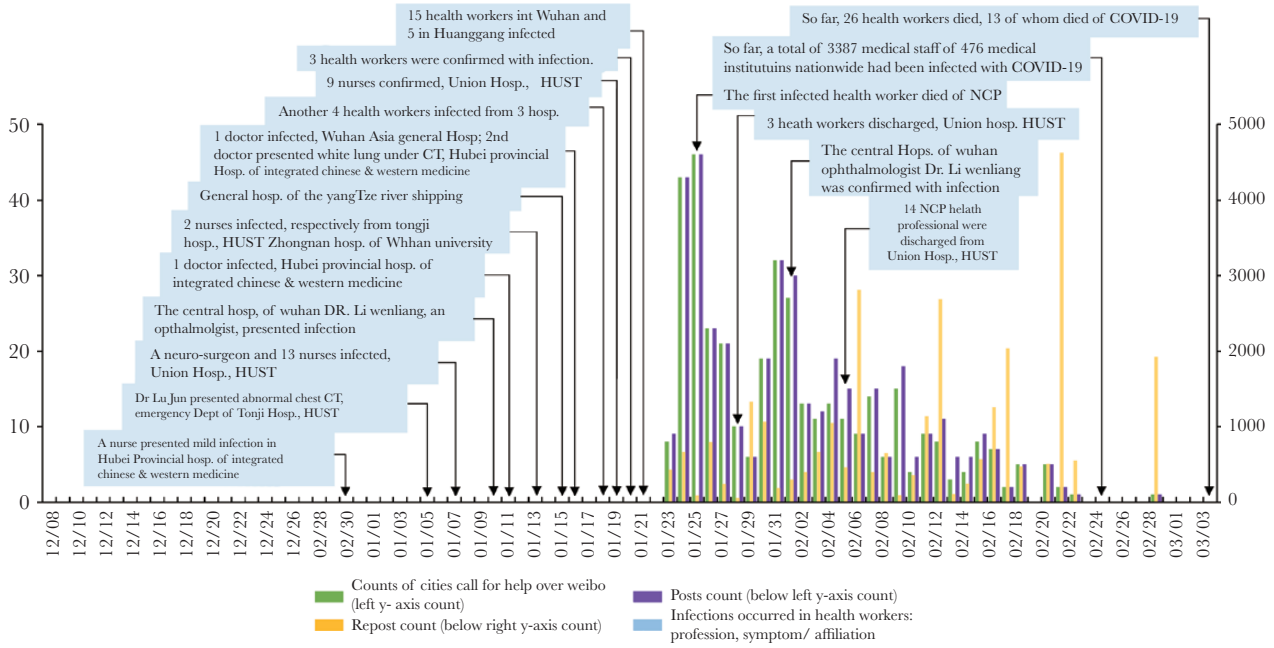

Figure 3. Timeline of coronavirus disease 2019 epidemic trend, supply-relevant policy changes, health care workers infected with severe acute respiratory syndrome coronavirus 2, posts and reposts of calls for help reflecting supply shortage of personal protective equipment (city number and overall posts) via Weibo. Abbreviations: COVID-19, coronavirus disease 2019; CT, computed tomography; HUST, Huazhong University of Science and Technology; NCP, novel COVID-19 pneumonia.

rotating the shift times as wearing PPE accelerates a sense of exhaustion in the medical workplace (3%). Over half of these respondents recommended compulsory training on self-protection standards. Some respondents suggested the need for attention to gender-related vulnerability in crises. One example was for female health workers to be allowed to take breaks during menstruation due to inconvenience with gowning and consequent potential of increasing infection risks. Over 10% of the respondents complained about an amateurish style of hospital leadership, for instance, exhibiting managerial incompetence with regards to achieving effective responses as well as exhibiting a lack of health care knowledge and professionalism (Supplementary Table 4).

DISCUSSION

Health workers' sense of self-confidence in addressing the COVID-19 pandemic response in China was highly dependent on their sense of confidence in the readiness of their hospital or institution to supply PPE and training in the use of protective measures. Typically prevention training and staff preparation are offered by the hospital as a component of their institutional responsibility. Institutional readiness is an important element of containing fear among frontline health workers. Increasing health workers' sense of confidence depends on a sufficient supply of PPE, a vital element of building societal confidence. Preventable nosocomial infections happened in mid- to late January [8], correlating with a time of PPE shortages, diminishing social confidence and spreading fear and panic among health workers. An earlier response to contain nosocomial transmission and to manage early cases might have obviated the need for more complex and harsh "social distancing" strategies instituted later to contain the drastic spread of COVID-19 in Hubei province.

Hospital supplies of PPE are a relevant and measurable indicator of institutional readiness in addressing the outbreak. Concerns about PPE supply shortages can devastate health workers' confidence in future responses. Other studies have similar findings, suggesting that common challenges include PPE supply, amateurish training of health workers, and full understanding of changing guidelines [9]. In China, clinical guidelines for COVID-19 were changed 7 times within 7 weeks, affected by officials' acknowledgment of person-to-person transmission, making intensive training around guidelines essential for hospital health care employees [10].

Other studies of institutional readiness have cited triage strategies, isolation management schemes, and training on the use of PPE and other protective measures [9]. These are highly compatible with findings from our study. Health workers are less confident in the preparedness of their hospitals than in their personal readiness. As hospital-level preparedness requirements are intensive and complex to battle outbreaks, our finding echoes that of an Ebola virus preparedness report from the United States [11]. Compulsory training on precautions and the application of universal standard guidelines, including PPE use, can reduce occupational infection and increase confidence during a crisis [9, 12]. Health emergency responders should

consider integrating grassroots–level simulation training for staff (primary and undetermined hospitals, clinics) to increase capacity and readiness for patient management [13].

We also found that health workers had more trust in the source of information when it was from the government than from other channels. This may be true in China, but could plausibly be the opposite in other nations. Chinese health authorities' timely disclosure of epidemic information likely increased a sense of security through viable up-to-date information in late January [10, 14, 15].

Better hospital infrastructure, worker satisfaction with PPE, and a worker's current sense of confidence in the hospital's current readiness seem to increase the self-confidence of health professional staff in addressing EIDs [16]. Outbreaks and epidemics mean that hospitals and frontline care facilities need products in unprecedented quantities [17]. Alongside the significant spike in product demand, health care workers can experience fear and panic, devastating the confidence of the public and health workers alike. This occurred when PPE distributors and manufacturers were unable to fill early orders for SARS-CoV-19 programs [5]. Hospitals and governments must address the needs for surging supply and stock via tiered advanced planning to cope with different epidemic scenarios [18, 19]. This phenomenon can also be seen in chronic pandemics; surges in HIV testing in Africa have created similar challenges in adequate stocking of provincial HIV test kits, antiretroviral drugs, and antituberculosis drugs, for example [20].

The confluence of PPE shortages and high infection rates in health workers early in the COVID-19 outbreak in China may be causal [21]. After the Asia-Pacific Strategy for Emerging Diseases and Public Health Emergencies issued in 2005 and updated in 2010 [22], the China Ministry of Health issued its response strategy for EIDs in 2007 [23]. They mandated outbreak preparedness training for all health workers. This included the need for relevant protective supply inventories and reservations-for-use [23]. Such requirements were updated and reiterated further in 2015–2019, such as the "Thirteenth Five-Year Plan" for the construction of the National Emergency Response System Office [24], the national "Thirteenth Five-Year Plan" for Prevention and Control of Emerging Infectious Diseases [25], guidance on health emergency response [26], and guidance on strengthening the construction of a natural disaster relief material reserve system [27] to improve management of material and technical reserves for all-hazards responses. Unlike the United States [28, 29], the Netherlands [11], or Singapore [30], China did not have an inventory tracking system for PPE, nor was PPE budgeted vis-à-vis outbreak scenarios or EID pandemics. No policy files specified or recommended a national PPE inventory for health workers' preparedness. Rather, China health authorities advocated for a "zero-reserve" medical materials policy in an effort to reduce medical costs [31]. This policy exacerbated the shortage of PPE in the early stage of the Wuhan outbreak. Hospital financial management measures issued in 1998 and updated in 2010 [31] required that inventory materials "be managed in accordance with the 'planned purchase and fixed-rate supply' approach." The management of low-value disposables used a method of "quantitative allocation and replacement of old ones with new ones." Most units of PPE have been included in these inventories, such that shortages were seen even in third-tier (top-level) hospitals in Wuhan and elsewhere in China. In government preparedness planning, policies did not match needs [15].

Study strengths were the ability to draw conclusions from mixed-methods results. That we could do the study in such proximity to the epidemic's geometric rise ensures the freshness of opinions of our respondents, minimizing recall bias. Our study has some limitations. Data crawling text information was gathered retrospectively. It may underestimate the actual quantity of postings asking for PPE help as some information that was shared by the institutions may have been taken down when their needs were met. Some information over the internet (such as criticisms of local responses) are more likely to be removed than other responses, making the current data an underestimate of gaps in preparedness. Changes in the trend of numbers may reflect either true product shortages or difficulties with supply chains over time. Our survey was a convenience web-based sample with a comparatively low response rate, limiting generalizability. However, this method was the only feasible way to avoid intra-person contact in data gathering during the pandemic crisis in China. As our survey was conducted after the PPE supply need was almost met after extreme scarcity, the satisfaction rate of the PPE supply may have been an overestimate.

CONCLUSIONS

Ensuring PPE supply for health workers is an essential inventory component for effective health emergency response, and PPE should be an integrated element in all-hazards emergency preparedness procedures. PPE availability increases a sense of confidence among health workers and reduces nosocomial infection. Tiered management, reasonable rotation, specified inventory of PPE for stockpile, and inventories that are ready-for-use for health workers are all vivid lessons from China for consideration by other global infection control fighters.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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Potential conflicts of interest. All authors: no conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

Author contributions. H.Y. is the principal investigator, and H.Y., H.D., and M.J. conceptualized the study; H.Y., H.D., and M.J. carried out the survey; G.J. crawled the Weibo information; S.W., L.M., L.Z., G.J., K.N., and H.D. performed data analysis and visualization; H.D. and H.Y. drafted the manuscript; H.Y. and S.H.V. interpreted the findings and edited and revised the manuscript. All authors approved the final versions of the submitted and published manuscripts.

Ethical approval. The study was approved by the Capital Medical University Ethics Review Board (2020SY004).

Informed consent. Obtained.

Data sharing. We have shared all the available data; if further details are needed, we would be glad to send them.

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