Surveillance of coronavirus disease 2019 in general population using an online questionnaire: A report from 18161 respondents in China

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Abstract

Background: The recent outbreak of coronavirus disease 2019 (COVID-19) has become an international pandemic. So far little is known about the role of an internet approach in COVID-19 surveillance.

Objective: We aim to investigate whether an online survey can provide population-level information for observing prevalence trends during early phase of outbreak and identifying potential risk factors of COVID-19 infection.

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Results: A total of 18161 questionnaires were returned, including 6% (1171) from Wuhan City. Geographical distributions of the respondents were consistent with population per province (R^2 = 0.61, P < .001). History of contact significantly decreased with time, both outside Wuhan City (R^2 = 0.35, P = .002) and outside Hubei Province (R^2 = 0.42, P < .001). Percentage of fever respondents peaked around February 8 (R^2 = 0.57, P < .001) and increased with history of contact in the areas outside Wuhan City (risk ratio: 1.31, 95% confidence interval: 1.13 - 1.52, P < .001). Male sex, advanced age, and lung diseases were associated with a higher risk of fever in the general population with history of contact.

Conclusions: This study shows the usefulness of an online questionnaire for surveillance of outbreaks like COVID-19 by providing information about trends of the disease and aiding in identifying potential risk factors.

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Keywords: coronavirus; surveillance; online questionnaire; Wuhan; COVID-19

Introduction

The recent outbreak of 2019 coronavirus disease (COVID-19) has caused over 752 thousand confirmed cases and 36 thousand deaths by March 30, 2020 [1-4]. Despite a proactive policy of identifying and treating patients with infected symptoms, it remains resource-intensive to screen the general population that is at risk of infection [5, 6]. Moreover, inequality of healthcare system among different areas also brings challenges to cover remote areas which are also at risk of the COVID-19 infection. Therefore, a new way to surveil the general population is likely to contribute to our understanding of COVID-19 [7]. The wide use of internet throughout China, and in the rest of the world, may be sufficient to provide such information. Participatory disease surveillance has been increasingly investigated in recent years as a promising tool to complement traditional facility-based surveillance platforms [8]. It has the advantage of quick coverage of a large population during disease outbreak. Because of this, an online survey may be valuable in monitoring disease trends in community and providing information for policy-making.

Here we report the results of the first online questionnaire of COVID-19, released since 24 January and with data collected up to 17 February 2020. Our study aims to investigate 1) how history of contact and fever, both defined according to relevant medical guidelines, have evolved during the early phase of government policy of lockdown, and 2) whether an online questionnaire can be used to identify certain risk factors related to fever among those reporting history of contact.

Methods

Questionnaire development and distribution

The first version of questionnaire was developed on 24 January 2020. By that time, little evidence was known about COVID-19. Our anonymous questionnaire was primarily developed from the following 3 sources: 1) the Diagnosis and Treatments of COVID-19 (Third Version) guideline; 2) clinical courses of the first 17 death cases, both of which released by the National Health Commission of China; and 3) an article which first analyzed the clinical features of 41 cases with COVID-19 [9-11]. The guideline requires a suspected case to satisfy the following criteria: 1) any history of contact: living in Wuhan or having travelled to Wuhan within 2 weeks of disease onset; being in contact with any person with fever and respiratory symptoms from Wuhan within 2 weeks of disease onset; belonging to a cluster of infected cases; 2) clinical manifestations: fever, defined as body temperature ≥ 37.3 ℃ (99.1 ℉); imaging evidence of COVID-19; normal white blood cell count or leukopenia or lymphopenia. A confirmed case is further established by positive findings of real-time polymerase chain reaction or viral gene sequencing. The descriptions of the guideline are in good consistency with the clinical features of the first 17 death cases and later 41 infected cases reported on 24 January [9, 10]. Therefore, our questionnaire evaluated the risk of COVID-19 in general population from the following aspects:

1) History of contact: living in Wuhan, or having travelled to Wuhan in the past 2 weeks; or had any close contact (lived, studied or worked together, or had any other close contact) in the past 2 weeks with a person with fever and cough who came from Wuhan; or workplace, school or family has at least 2 confirmed cases. Other history of contact with wildlife animals within 2 weeks of disease onset was also considered.

2) Body temperature: having a fever with body temperature higher than 37.3 ℃ (99.1 ℉).

3) Symptoms: We classified symptoms by their relative importance into the following 3 groups: 1. Chief symptoms related to pulmonary infection, i.e., cough without sputum or with little sputum, and

shortness of breath; 2. Secondary symptoms related to systemic changes probably caused by viral infection, i.e., fatigue, headache, and myalgia; and 3. Probably unrelated symptoms, i.e., nasal obstruction, rhinorrhea, sneezing, sore throat, and diarrhea.

4) Comorbidities: Lung diseases, cardiovascular diseases, hypertension, diabetes, stroke and chronic kidney dysfunction.

5) Basic information: age and gender.

We did not include laboratory examinations (e.g. real-time polymerase chain reaction, lymphopenia, white blood cell count) or thoracic imaging results (e.g., multiple patchy consolidation and interstitial changes) in our questionnaire because in general they are unlikely obtained by general population.

By 17 February 2020 we had developed and released three versions of Chinese questionnaires to the public. They were essentially similar, with the following three major revisions: 1) We divided the age group of ≤ 40 years, used in the first version, into age groups of ≤ 30 years and 31 – 40 years in the following two versions for better risk stratification; 2) History of contact with wildlife animals was removed from the third version because we considered it to have a low value for diagnosis in general population; and 3) the question, initially included for evaluating shortness of breath (“I feel extremely short of breath when climbing upstairs or walking at a fast speed”, modified from the Medical Research Council Breathlessness scale) was removed from the third version, and added as an item named “shortness of breath” to the question about symptoms of COVID-19. This was done, because we found an exceptionally high percentage of respondents reporting shortness of breath in the first 2 versions of questionnaires (26.5% and 32.9%, respectively).

After completing the questionnaire, the respondents would be classified into one of the following 4 risk groups and given different suggestions: 1) High risk group having history of contact and fever: they were suggested to measure their body temperature after 30 minutes and immediately visit hospital to screen for potential COVID-19; 2) Moderate risk group having history of contact but

without fever: they were suggested to daily monitor their body temperature and screen for potential COVID-19 if fever or respiratory symptoms occur; 3) Low risk group without history of contact but with fever: this group probably had a common cold, and was suggested to make an appointment with general practitioner for help if necessary; 4) Very low risk group without history of contact or fever: they were unlikely to have COVID-19 at the time they completed the questionnaire and were suggested to take necessary measures such as putting on a facemask to prevent the infection.

The questionnaire was developed using a professional online questionnaire website Wenjuanxing (Questionnaire Star) [12]. It is the most popular website for online survey in China with over 4.2 billion questionnaires recycled and over 59 million users by 21 February 2020. Questionnaires were distributed online by 1) WeChat, the most popular instant message application in China, and 2) sharing the link of the questionnaire. Since our aim was to have an overview of situations in China during COVID-19 outbreak, we did not target any specific groups of respondents of interest. Distribution and filling of the questionnaires were voluntary behaviors, making our study a convenience sampling study.

According to the World Health Organization Guidelines on Ethical Issues in Public Health Surveillance, a surveillance study in emergency outbreak situations is clearly exempted from ethical review and oversight [13]. Indeed, our online questionnaire was designed on 23 January when the lockdown of Wuhan City was officially announced and released on the day followed, so it could not await the formal approval of an ethical review of committee. All users were informed at the beginning of the questionnaire that their questionnaire data would be used only for medical education and research purposes. If the informed consent was rejected by the users, they still could continue the questionnaire and obtain their results.

Data collection

The questionnaire was released on 24 January and recycled on 17 February. All questionnaire results were downloaded from the website for our analysis. In addition to the items of the

questionnaire, the downloaded data also included date of submission of all respondents as well as respondents' location on city level.

We also collected population data of each province from China Statistical Abstract 2019 published by the National Bureau of Statistics of China [14]. The number of confirmed cases was followed up on a daily basis since release of the questionnaire using the NetEase News website, the largest Chinese hub for real-time collection of COVID-19-related data and news [15]. The statistics of confirmed cases per province used in this study were collected until midnight of February 11, because at that time also clinically diagnosed cases without positive real-time polymerase chain reaction results were included in the officially confirmed number of cases.

Statistical analysis

Count data were expressed as number (percentage). Skewed continuous data (time to complete questionnaire) were expressed as median (25th percentile – 75th percentile). Geographical distributions were drawn using Microsoft Excel Visual Basic. Pearson's correlation analysis was used to analyze the relationship between two variables of interest (mainly between date and percentage of respondents of interest per day). Comparison of respondents' basic characteristics between inside and outside Wuhan was performed using *chi-squared* test or Fisher's exact test if sample size < 40. Risk of fever in respondents with history of contact was evaluated using risk ratio (95% confidence interval) [RR (95% CI)]. All statistical analyses were performed using Stata 14.0 and MATLAB R2018b. Statistical significance was defined as a two-tailed *P* value smaller than .05.

Results

By 17 February 02:33 AM, a total of 19449 individuals completed the questionnaires, 97% from China. After removing 385 questionnaires from overseas countries, 575 lacking informed consent, 55 missing age, 31 missing temperature, 38 missing comorbidities, and 4 missing symptoms information, 18161 anonymous questionnaires were analyzed. Overall, it took 52 (41 - 67) seconds to complete the questionnaire. Most questionnaires were accessed by clicking on the link of the questionnaire (11337, 62%) and by visiting WeChat miniApp (6800, 37%).

Geographical distributions

Figure 1A shows the geographical distributions of the questionnaire respondents in China. The questionnaire covered all 34 province-level administrative regions. For Hubei Province, 69% (1171) of respondents came from Wuhan City which was mostly affected by COVID-19. A positive relation was found between the number of respondents and the population size per province (**Figure 1B**), demonstrating good coverage of the questionnaire across China.

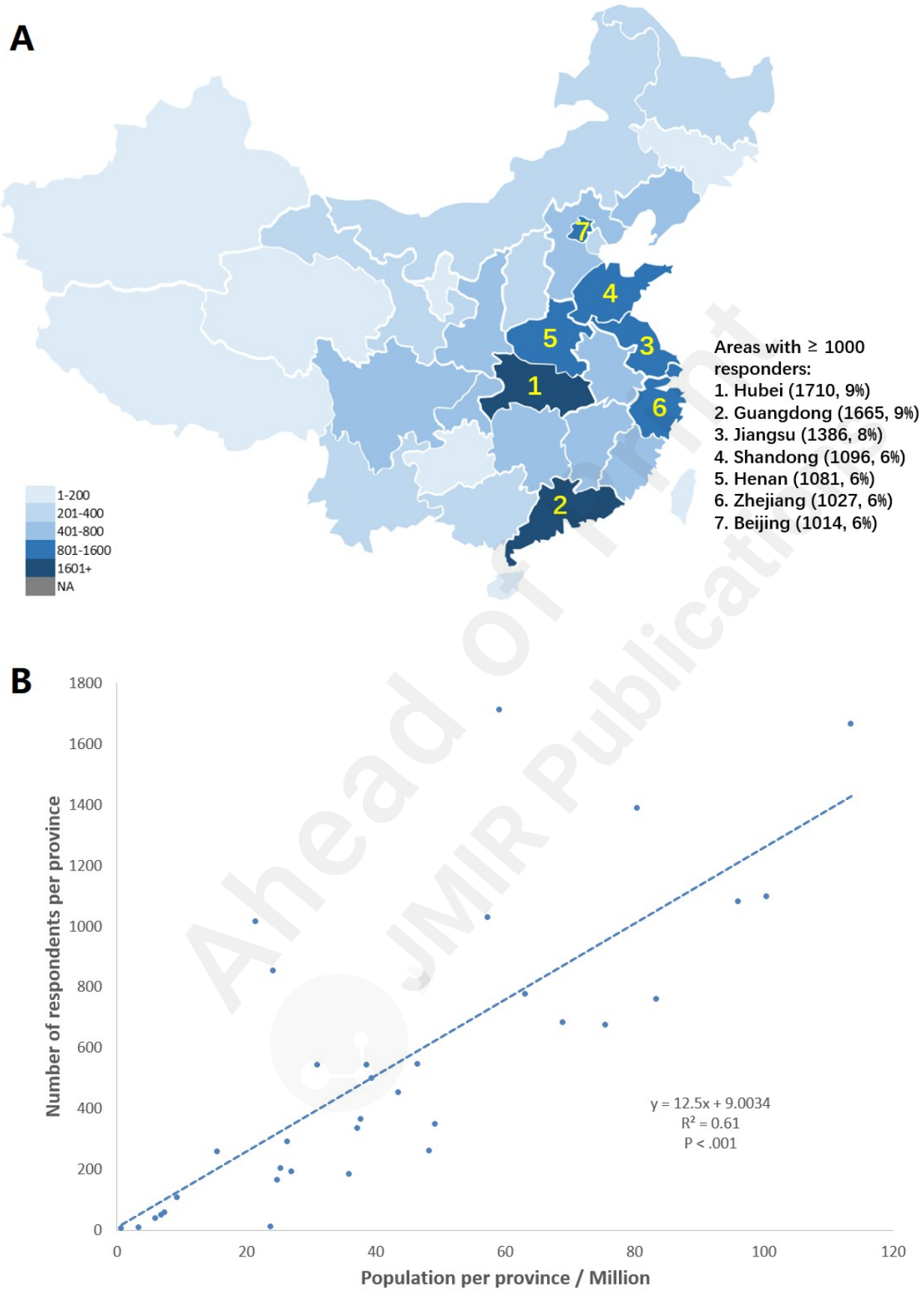

Figure 1 A) Geographical distributions of questionnaire respondents in China. B) A positive correlation between the number of respondents and the size of the population of each province.

Basic characteristics

Table 1 summarizes the demographics and basic characteristics of respondents. The population in Wuhan had similar age and comorbidities to that of outside Wuhan. Age was negatively correlated with the number of respondents (R^2 = 0.95, P < .001). As expected, history of contact was more frequent among the respondents living in Wuhan (all P < .001). The percentage of fever was significantly lower among respondents inside versus outside Wuhan. Symptoms were reported in a rather high percentage (65%) of respondents. When restricting the symptoms to at least 1 main symptom and 1 secondary symptom, the number of respondents with symptoms dropped to 13% (2292).

Table 1. Demographics and basic characteristics of respondents

	All respondents (n = 18161)	Wuhan (n = 1171)	Outside Wuhan (n = 16990)	*P* value
Women	10801 (59%)	762 (65%)	10039 (59%)	< .001
Age, years				
≤ 30	12504 (69%)	782 (67%)	11722 (69%)	.11
31 – 40	3757 (21%)	282 (24%)	3475 (20%)	.003
41 – 50	1154 (6%)	70 (6%)	1084 (6%)	.59
51 – 60	532 (3%)	28 (2%)	504 (3%)	.26
61 – 70	147 (0.8%)	6 (0.5%)	141 (0.8%)	.24
≥ 71	67 (0.4%)	3 (0.3%)	64 (0.4%)	.51
Any comorbidity	1593 (9%)	95 (8%)	1498 (9%)	.41
Hypertension	655 (4%)	38 (3%)	617 (4%)	.49
Lung diseases	468 (3%)	24 (2%)	444 (3%)	.24
Cardiovascular diseases	375 (2%)	21 (2%)	354 (2%)	.50
Diabetes	223 (1%)	16 (1%)	207 (1%)	.66
Chronic kidney disease	135 (0.7%)	5 (0.4%)	130 (0.8%)	.19
Stroke	34 (0.2%)	4 (0.3%)	30 (0.2%)	.21
Any history of contact	2631 (14%)	1171 (100%)	1460 (9%)	< .001
Living in Wuhan now or having gone to Wuhan in the past 2 weeks	1950 (11%)	1171 (100%)	779 (5%)	< .001
Contacts with a person with fever and cough from Wuhan in the past 2 weeks	938 (5%)	298 (25%)	640 (4%)	< .001
At least 2 confirmed cases in workplace, school or family	532 (3%)	122 (10%)	410 (2%)	< .001
Fever	1653 (9%)	56 (5%)	1597 (9%)	< .001
Any symptom	11796 (65%)	699 (60%)	11097 (65%)	< .001
Cough	5242 (29%)	314 (27%)	4928 (29%)	.11

Shortness of breath	4393 (24%)	263 (22%)	4130 (24%)	.15
Nasal obstruction, rhinorrhea, or sneezing	4376 (24%)	237 (20%)	4139 (24%)	.001
Sore throat	3397 (20%)	201 (18%)	3196 (20%)	.16
fatigue	3245 (18%)	148 (12%)	3097 (18%)	< .001
headache or myalgia	2072 (11%)	87 (7%)	1985 (12%)	< .001
Diarrhea	1360 (8%)	70 (6%)	1290 (8%)	.04

History of contact

History of contact was reported in 2631 (14%) respondents. However, the high percentage might have been confounded by considering all respondents living in Wuhan City as having history of contact according to the definition of official guideline, so we excluded these respondents from our analysis and divided the remaining respondents by every 8 days into 3 phases: 1) phase 1: 24 to 31 January; 2) phase 2: 1 to 8 February; and 3) phase 3: 9 to 16 February. Despite heterogeneous responses of different provinces, proportion of respondents reporting history of contact had markedly decreased over these 3 phases in most provinces (**Figures 2A, B, C**). This observation was further confirmed by correlation analysis between the proportion of respondents reporting history of contact and date in areas outside Wuhan City and Hubei Province (**Figure 2D**). These findings indicate the efficacy of current policies adopted to reduce the history of contact among general population since a lockdown in Wuhan and other areas on January 23.

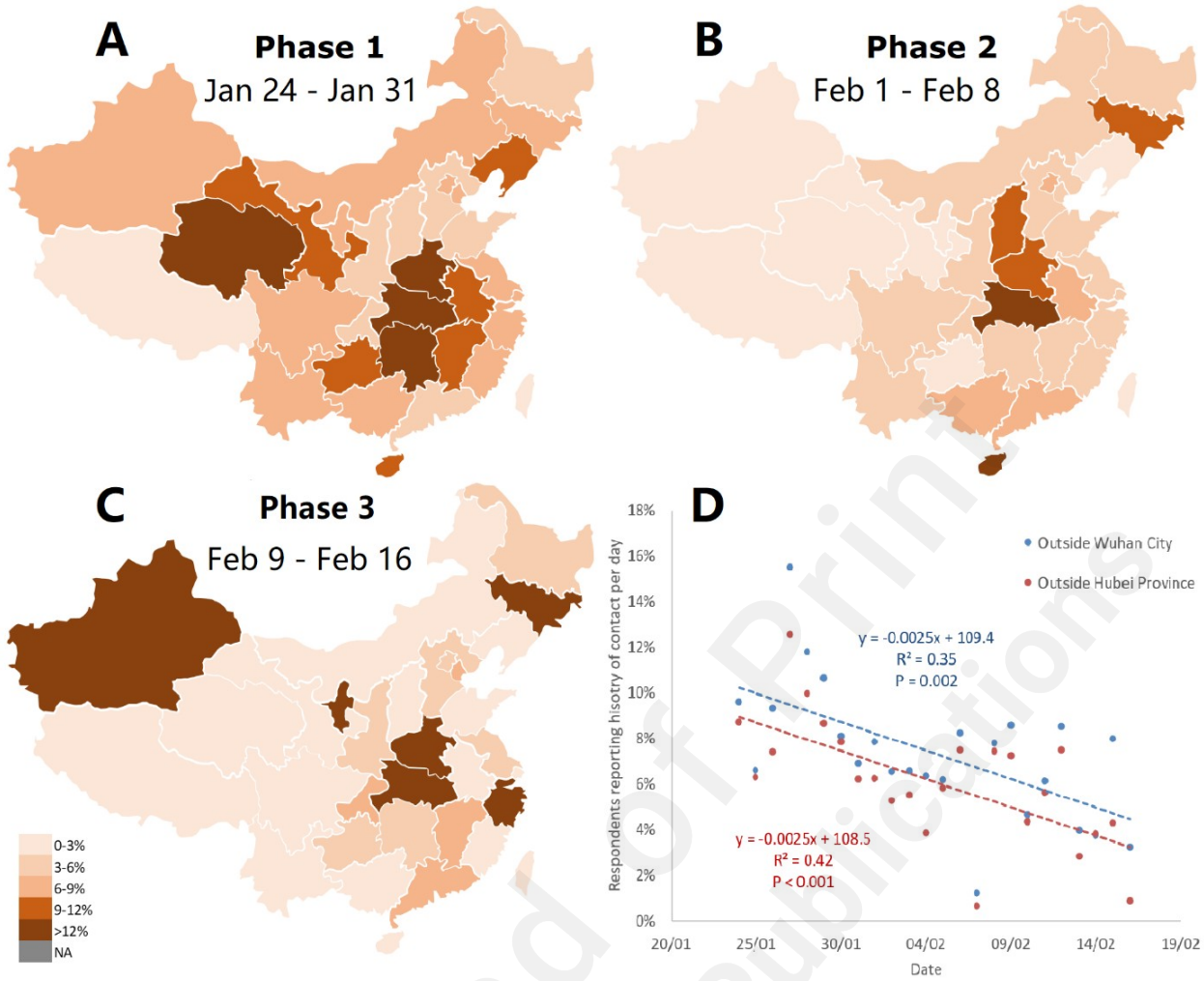

Figure 2. Geographic spread of the proportion of respondents reporting history of contact in three phases of the COVID-19 outbreak (A, B, C) and its time course in all regions outside Wuhan City and outside Hubei Province (D).

Body temperature

Body temperature was measured in 77% (14073) of respondents, with a higher percentage in Wuhan City (85%, 990) and Hubei Province (84%, 1431), respectively. Overall, fever was reported in 9% (1653) of respondents. Unexpectedly, a lower percentage was found for Wuhan City and Hubei Province (5% for both). This might be due to that as COVID-19 developed to a further stage in Wuhan, fever cases were identified early and sent to hospitals without access to internet. We further analyzed how the percentage of respondents with fever evolved with time. The trend seemed

to peak on around February 8 (**Figure 3**).

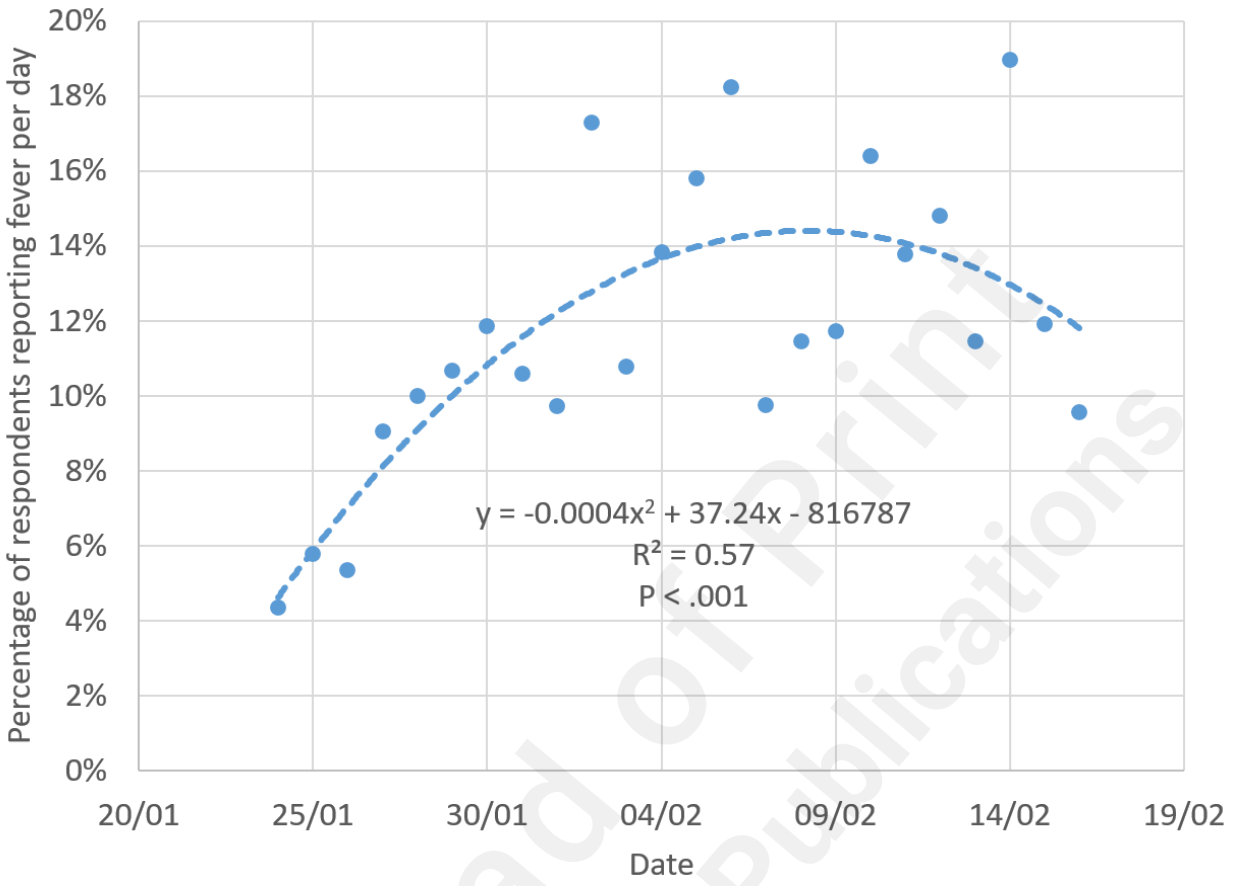

Figure 3. Proportion of respondents reporting fever over time.

Fever in respondents with history of contact

To analyze the relationship between fever and history of contact may help develop population-based strategies for prevention purpose. For the respondents living outside Wuhan, we found a significant relation between any history of contact and fever (RR: 1.31, 95% CI: 1.13-1.52, $P < .001$). Travelling to Wuhan, having any close contact with confirmed case, and having at least 2 confirmed cases at workplace in the past 2 weeks conferred a significantly higher risk of fever (RR: 1.47, 95% CI: 1.23-1.77, $P < .001$; RR: 1.98, 95% CI: 1.67 - 2.24, $P < .001$; and RR: 2.12, 95% CI: 1.74 – 2.58, $P < .001$, respectively). Moreover, there was a significant positive relation between the number of officially confirmed cases and the number of respondents reporting fever ($R^2 = 0.41$, $P < .001$) or the

number of respondents reporting fever plus history of contact ($R^2 = 0.35$, $P < .001$) on a province basis. Regarding risk stratification based on history of contact and fever, most respondents (14264, 79%) were classified to very low risk group, followed by moderate (1883, 10%) and low risk group (1428, 8%), whereas only 1% (225) to high risk group.

Furthermore, comparison of fever rates among groups of various characteristics was likely to help identify risk factors (**Figure 4**). Males were at a higher risk of fever than females (P < .001). There was a positive trend between age and fever (P < .001). Respondents reporting fatigue and headache/ myalgia were more likely to report fever (P < .001). Comorbidities showed various associations with fever, among which history of lung diseases seemed to confer a higher risk of fever than the others. However, the relationship needs to be further validated by larger-sample studies because of a relatively small number of respondents in each group.

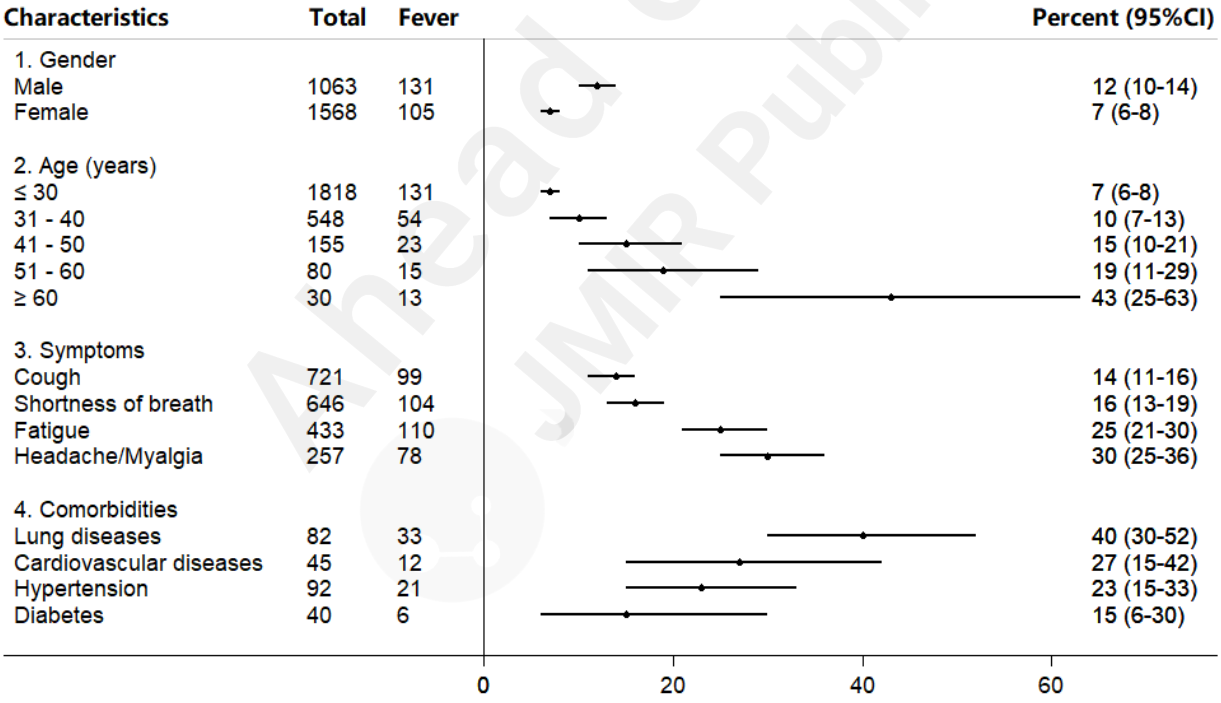

Figure 4. Fever in various subgroups of respondents with history of contact

Discussion

To the best of our knowledge, this is the first large-sample online surveillance of COVID-19 outbreak in general population. Our major findings are: 1) our questionnaire had a good coverage of all provinces of China in a relatively short period of time (~3 weeks); 2) history of contact among population outside Wuhan and Hubei Province significantly decreased during the early phase of government policy of lockdown; 3) fever reported by respondents significantly increased in short term of disease outbreak and levelled off in 2 to 3 weeks; and 4) among those with history of contact, some factors (male, an advanced age and history of lung diseases) seemed to be associated with a higher risk of fever.

Values of online questionnaire

An online questionnaire is likely to serve as a complementary way of disease surveillance in general population, especially during the emergent outbreak of an infectious disease [5]. It takes the advantage of low-cost and efficient delivery to all areas even the most remote areas where internet access is better than health care resources [16, 17]. Our questionnaire included 3% (385) Chinese respondents from 38 overseas countries, including developed (the United States, Japan, Canada, the United Kingdom), developing (Brazil, Russia, India, South Africa) and underdeveloped countries (Laos, Uganda, Cambodia). Translation of the questionnaire to other languages may further increase the coverage across the world and improve surveillance of the COVID-19 outbreak and comparable epidemics.

Compared with the conventional way of disease surveillance, the online questionnaire covers the population generally with less severe conditions but nevertheless is under risk of infection [7, 18]. Taking into account this population helps to establish the full spectrum of COVID-19 epidemiology. It may also facilitate the early triage and diagnosis of high-risk groups when combining with other digital health measures such as online physician consultation which has been widely adopted since

COVID-19 outbreak in China. For the low-risk population, the questionnaire can also be adapted to reduce unnecessary anxiety and hospital visits and thus greatly relieve the workloads of healthcare facilities especially when an emergent public health event occurs [19].

The questionnaire approach is advantageous compared with other approaches of online disease surveillance using data from the Google Trends, Twitter, or Facebook [20-22]. It provides richer information of the respondents because most items can be designed according to medical guidelines and characteristics of target population. Therefore, it is a more active approach than other infosurveillance methods using social media. The information such as symptoms, history of contact and comorbidities provided by an online questionnaire can be further combined with vital data such as body temperature, heart rate, respiratory rate, oxygenation level and activity level obtained from wearable devices to have a more comprehensive and reliable estimation of respondent's risk of disease [23]. For the high-risk group identified using an online questionnaire, a case can be further confirmed by sending a home testing kit and instructing the respondents to perform a rapid diagnostic test, as shown in the GoViral study [24]. Additionally, self-reported data from an online questionnaire can be linked with electronic medical records to build a long-term monitoring system [8].

Use of questionnaire to observe trends

An online survey is likely to be used to observe the trends of disease prevalence in community and thus support government policy evaluation. In our study, the date February 8 when the percentage of fever respondents peaked was 16 days following lockdown of Wuhan City, close to the 14 days of the maximum incubation period of coronavirus [25]. The delay of fever peak might be associated with delayed quarantine policies in other cities in China. Overall, our data support the efficacy of current policies (quarantine, social distancing, and isolation of infected population) for containing the spread of COVID-19 from Wuhan City to the other areas of China [6, 26, 27]. However, the period

and efficacy of quarantine may differ by country [28]. It depends on not only government policies but also local culture and more importantly active supports from general population. For the other countries which may not have quarantine policies as strict as that of China the time to fever peak is probably longer among general population. Moreover, integration of survey data in a model for real-time and long-term forecasting of disease trends is likely to provide richer information for policy-making [29]. Of note, our questionnaire is more applicable to those living in China than abroad. Definition of history of contact has been mostly relied on contact with a confirmed case from Wuhan. However, this can be further modified according to the earliest and generally most severely affected area of a country of interest, such as Lombardy in Italy.

Use of questionnaire to identify risk factors

Our survey also indicates that some factors such as male, an advanced age and history of lung disease are likely to relate to a higher risk of infection and thus these groups should be under close observations. Indeed, these risk factors identified from our study are consistent with the clinical features of infected cases in previous publications [9, 30-33]. Opportunities are that with a quick dissemination of an online questionnaire during the early phase of disease outbreak, risk factors can be identified at a much earlier phase than when enough severe cases have been collected and analyzed using a conventional surveillance method. This further allows for an earlier protection of vulnerable groups from potential infection and thus reducing the number of cases. Internet-based surveillance approach based on Twitter has been demonstrated to detect Ebola, avian influenza and thunderstorm asthma at an early stage, even before the first official report [20-22].

Limitations of the approach

The approach undoubtedly has the bias of sampling primarily internet users and their relatives. As a consequence, the population included in our study is relatively young. Previous study demonstrated

that both too young (age 0 – 10 years) and too old (age over 81 years) populations are under-represented in an internet-based monitoring survey [34]. A better coverage of general population with high representativeness generally requires a more complicated study design together with robust supports from an official institution [8]. The questionnaire can also be distributed through other web platforms such as Sina Weibo (the most popular microblogging website in China) and news media (NetEase and Xinhua) which have a wider reach of respondents in China. Also, this study does not include a follow-up of individual patients. This choice was made in order to respect the respondents' privacy. However, in future studies it may be acceptable to allot an individual code to each individual, thereby allowing follow-up, although systematic follow-up will remain a problem with internet questionnaires. Follow-up may be further compromised by the lack of internet access when the individual is hospitalized.

Unlike hospitals which diagnose COVID-19 using a comprehensive set of laboratory and imaging examinations, we did not include diagnostic tests such as real-time polymerase chain reaction or lung computed tomography results in our questionnaire. Therefore, evaluating the respondents' risk of viral infection from history of contact, body temperature, symptoms and comorbidities may have the risk of underestimating some asymptomatic or presymptomatic patients who are not uncommon [35, 36].

Based on this study, we have updated our fourth version of Chinese questionnaire [37] and released the English questionnaire [38] (also see the **appendix** for Word format files). Both questionnaires follow the Attribution 4.0 International (CC BY 4.0) license, meaning that they are free to be shared and adapted under the condition that current work has been properly cited. Considering privacy purpose, the survey data of this study can be obtained from the corresponding author at request.

Conclusions:

In conclusion, this study shows that an online questionnaire may help monitor current prevalence,

evaluate government policy and identify high-risk population during COVID-19 outbreak. The online questionnaire approach can also be adapted to monitor other types of infectious diseases depending on areas of interest.

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Conflicts of Interest:

None declared.

Abbreviations:

COVID-19: 2019 coronavirus disease

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Supplementary Files

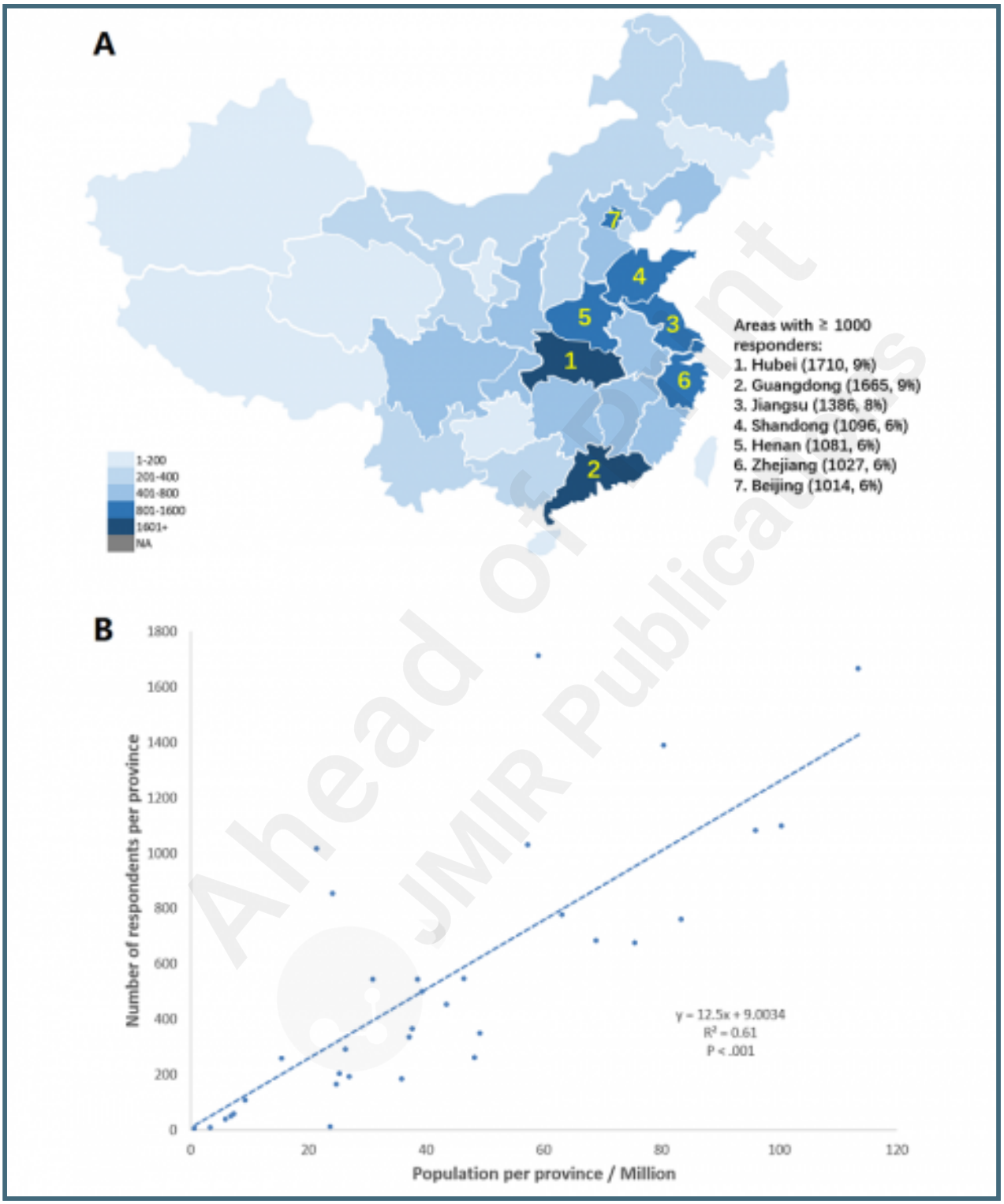
Multimedia Appendixes

Coronavirus Infection Risk Self-Assessment Questionnaire (CIRSAQ 4.0).
URL: https://asset.jmir.pub/assets/521c3c54b5b56df11d4eb360c2e16894.docx

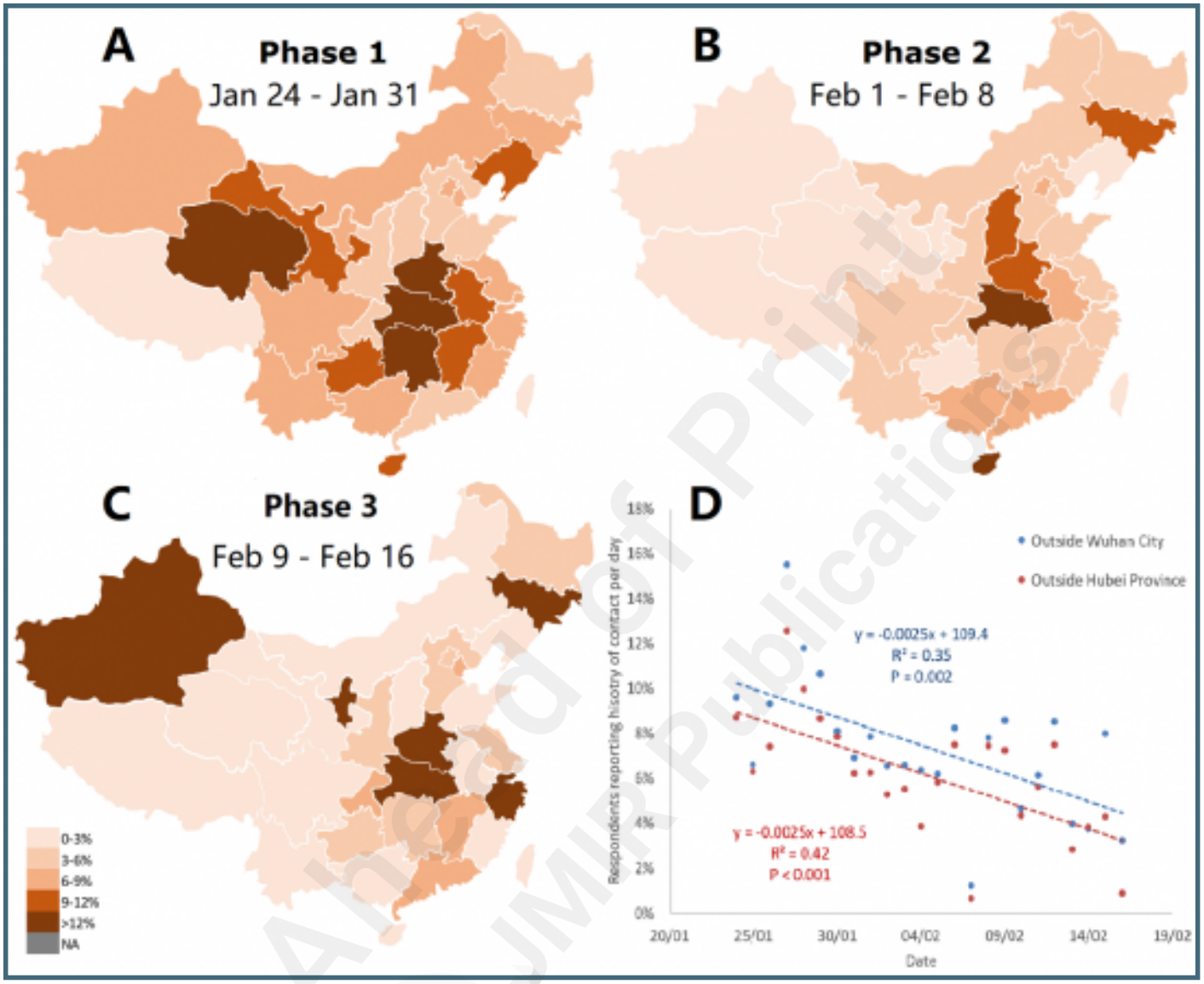
Coronavirus Infection Risk Self-Assessment Questionnaire (CIRSAQ 4.0) - Chinese Simplified.
URL: https://asset.jmir.pub/assets/9b211d3af00646ce77c3525db81b62ed.docx

Figures

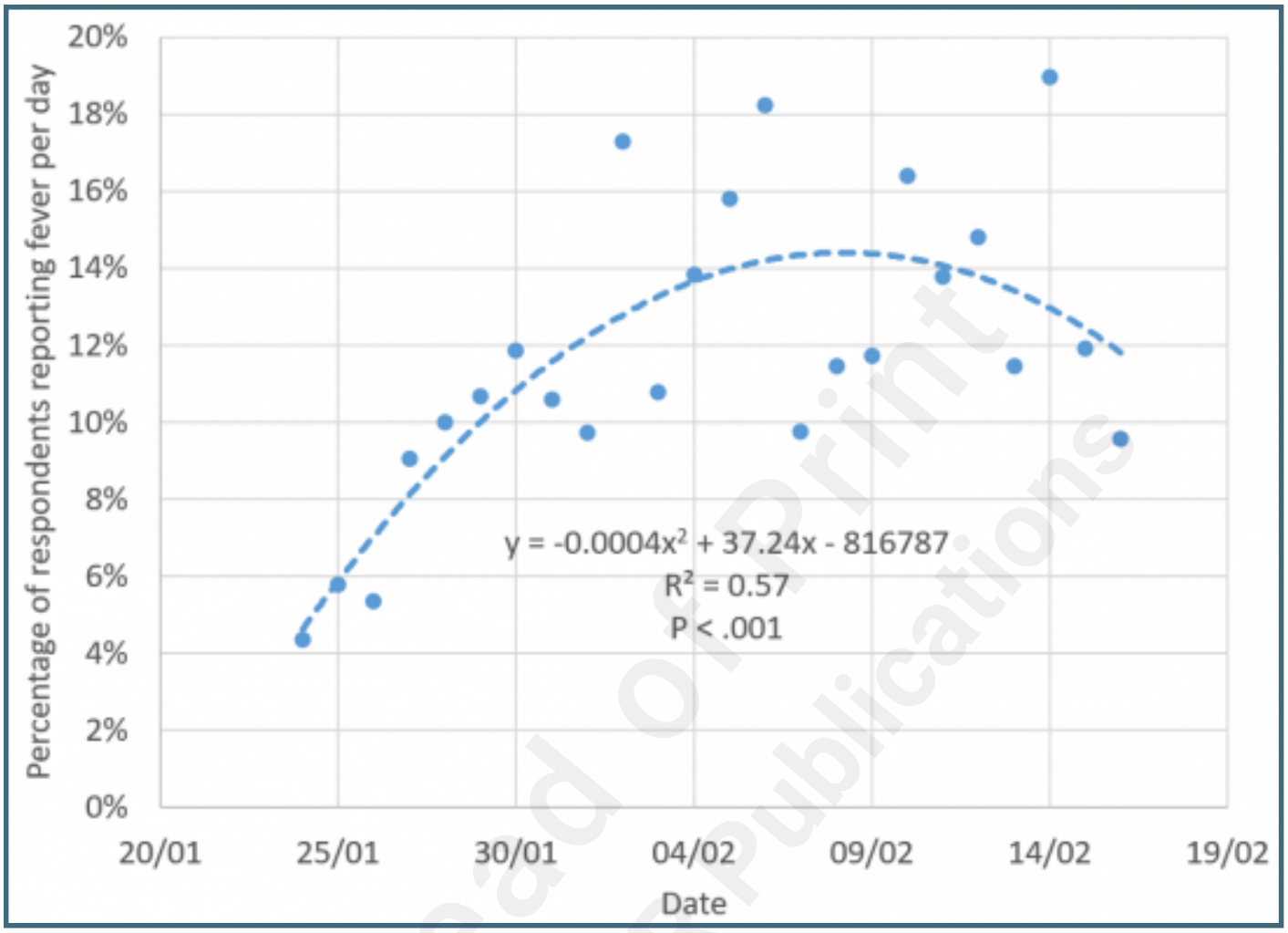
A) Geographical distributions of questionnaire respondents in China. B) A positive correlation between the number of respondents and the size of the population of each province.



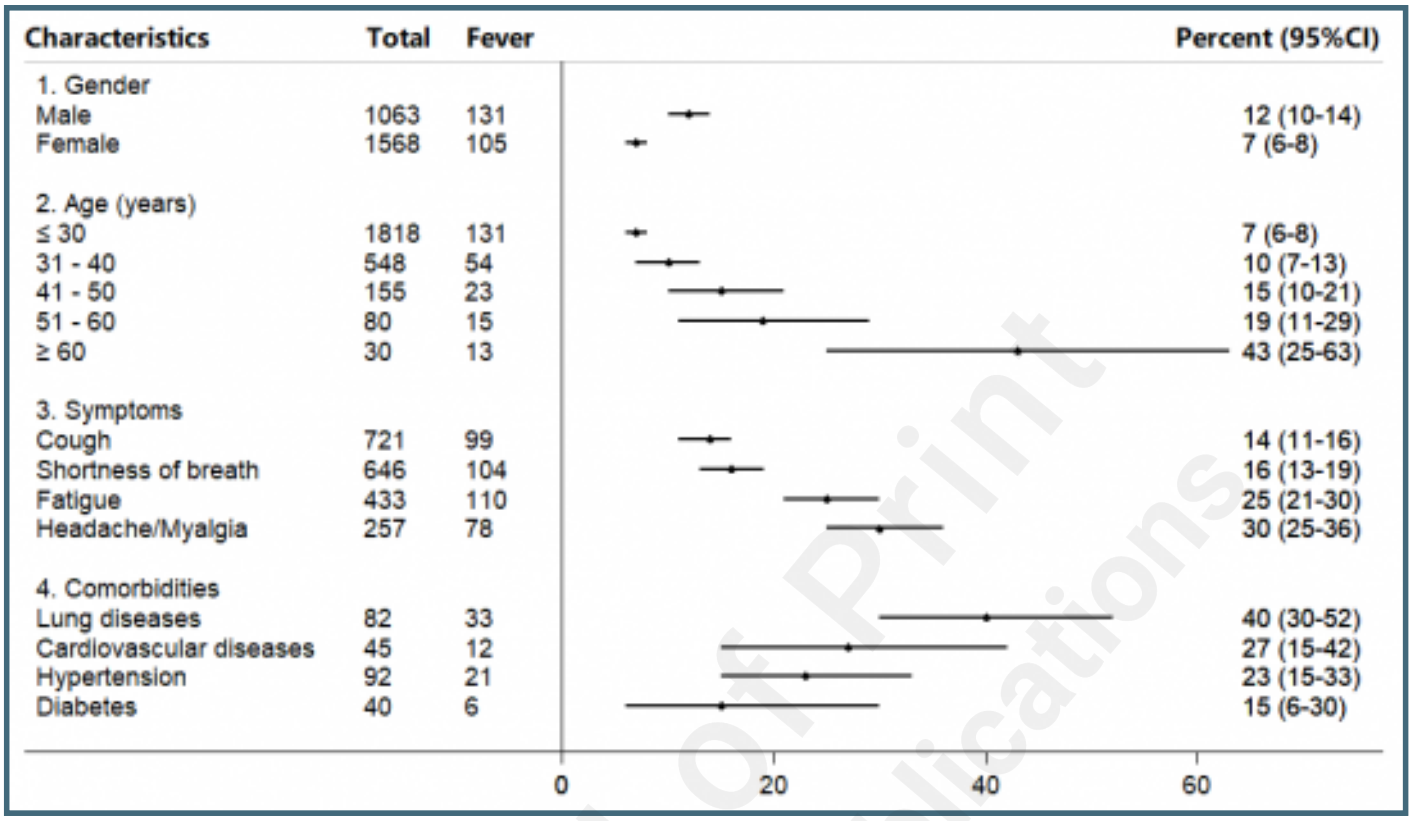
The geographic spread of the proportion of respondents reporting a history of contact in three phases of the COVID-19 outbreak (A, B, and C), and its time course in all regions outside Wuhan City and Hubei Province (D).



Proportion of respondents reporting a fever over time.



Fever in various subgroups of respondents with history of contact.



Other materials for editor/reviewers onlies

Responses to editor/reviewers.
URL: https://asset.jmir.pub/assets/2a6bdf6e9d7e31a37bb218cbfba38b29.docx