Self-reported compliance with personal preventive measures among 3035 Chinese factory workers at the beginning of work resumption following COVID-19 outbreak: a cross-sectional online survey

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Table of Contents

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Abstract

Background: Maintaining compliance with personal preventive measures is important to achieve the balance of COVID-19 pandemic control and work resumption.

Objective: This study investigated self-reported compliance with four personal preventive measures against COVID-19 among a sample of factory workers in Shenzhen, China at the beginning of work resumption in China following the COVID-19 outbreak. These preventive measures included consistent facemask wearing in any public spaces (workplace and other public settings), sanitizing hands using soaps/liquid soaps/alcohol-based hand rubs after returning from public spaces/touching public installations/equipment, avoiding meal/social gathering and avoiding crowded places. We also examined the effects of factors including socio-demographics, individual-level factors (knowledge, perception, and depressive symptoms), interpersonal-level factors (exposure to COVID-19 specific information through different media), and social structural-level factors (preventive measures implemented by the factories).

Methods: Participants were adult factory workers who had resumed work in Shenzhen, China. A stratified two-stage cluster sampling design was used. Fourteen out of 100 factories that had resumed work were randomly selected. All full-time employees aged ?18 years who had resumed work in these factories were invited to complete an online survey. A designated coordinator responsible for COVID-19 control in each factory facilitated the data collection. Out of 4158 workers who had resumed work in these factories, 3035 (73.0%) completed the online survey during March 1-14, 2020. Multilevel logistic regression models were fitted.

Results: Among participants, 96.8% (n=2,938) and 98.7% (n=2,996) reported wearing a facemask every time in the workplace and in other public settings in the past month, respectively. However, self-reported sanitizing hands (70.9%, n=2,152), avoiding social/meal gathering (73.3%, n=2,225) and avoiding crowded places (65.8%, n=1,997) were relatively low. After adjusting for significant background characteristics, at the individual level, knowledge about COVID-19 (adjusted odds ratio [AOR]:

1.16-1.29), perceived risk (AOR: 0.58-0.85) and severity (AOR: 1.05 & 1.07) of COVID-19, perceived effectiveness of individual (AOR: 1.05-1.09), organizational (AOR: 1.30) and governmental preventive measures (AOR: 1.14-1.21), perceived preparedness to potential outbreak after work resumption (AOR: 1.10-1.50) and depressive symptoms (AOR: 0.87) were associated with self-reported compliance with at least one personal preventive measures. At interpersonal level, exposure to COVID-19 specific information through official media channels (AOR: 1.08) and face-to-face communication (AOR: 0.90) were associated with self-reported sanitizing hands. The number of preventive measures implemented within workplace was positively associated with self-reported compliance with all four preventive measures (AOR: 1.30-1.63).

Conclusions: Measures to strengthen hand hygiene and physical distancing among factory workers are needed to reduce transmission following work resumption. Future programs within workplaces should address multilevel factors.

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Abstract

Background: Maintaining compliance with personal preventive measures is important to achieve the balance of COVID-19 pandemic control and work resumption.

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Methods: Participants were adult factory workers who had resumed work in Shenzhen, China. A stratified two-stage cluster sampling design was used. Fourteen out of 100 factories that had resumed work were randomly selected. All full-time employees aged ≥18 years who had resumed work in these factories were invited to complete an online survey. A designated coordinator responsible for COVID-19 control in each factory facilitated the data collection. Out of 4158 workers who had resumed work in these factories, 3035 (73.0%) completed the online survey during March 1-14, 2020. Multilevel logistic regression models were fitted.

Results: Among participants, 96.8% (n=2,938) and 98.7% (n=2,996) reported wearing a facemask every time in the workplace and in other public settings in the past month, respectively. However, self-reported sanitizing hands (70.9%, n=2,152), avoiding social/meal gathering (73.3%, n=2,225) and avoiding crowded places (65.8%, n=1,997) were relatively low. After adjusting for significant background characteristics, at the individual level, knowledge about COVID-19 (adjusted odds ratio

[AOR]: 1.16-1.29), perceived risk (AOR: 0.58-0.85) and severity (AOR: 1.05 & 1.07) of COVID-19, perceived effectiveness of individual (AOR: 1.05-1.09), organizational (AOR: 1.30) and governmental preventive measures (AOR: 1.14-1.21), perceived preparedness to potential outbreak after work resumption (AOR: 1.10-1.50) and depressive symptoms (AOR: 0.87) were associated with self-reported compliance with at least one personal preventive measures. At interpersonal level, exposure to COVID-19 specific information through official media channels (AOR: 1.08) and face-to-face communication (AOR: 0.90) were associated with self-reported sanitizing hands. The number of preventive measures implemented within workplace was positively associated with self-reported compliance with all four preventive measures (AOR: 1.30-1.63).

Conclusion: Measures to strengthen hand hygiene and physical distancing among factory workers are needed to reduce transmission following work resumption. Future programs within workplaces should address multilevel factors.

Keywords: Factory workers; facemask wearing; hand hygiene; physical distancing; work resumption

Introduction

As of July 1, 2020, 10,357,662 cases of COVID-19 have been reported worldwide, including 508,055 deaths [1]. China reported 85,232 confirmed COVID-19 cases and 4,648 deaths [1]. To curb the epidemic, the Chinese government formally requested enterprises to not resume work prior to February 10, 2020, with the exception of those involved in providing basic and essential services [2,3]. These strict control measures were shown to be effective but were likely detrimental to the economy [1], as China reported a 6.8% decline in its first quarter Gross Domestic Product in 2020 as compared to one year ago [4] (background of the study was shown in Figure 1).

In China, full work resumption is imminent. Starting from February 10, 2020, the Chinese government has implemented guidelines to ensure enterprises are adequately prepared for work resumption. Each enterprise must establish a comprehensive contingency plan, appoint a designated coordinator, monitor the health status of all employees and their travel history, and ensure the supply of all necessary prevention equipment [2,3]. Local governments will assess the preparation and grant official permission for work resumption [2,3]. In order to scale up work resumption, official permission from local governments is no longer required starting February 20, 2020 in some Chinese cities (e.g., Shenzhen) [2]. There are concerns that an increase in public contact after work resumption might result in second wave of COVID-19 outbreak in China [5].

Maintaining compliance with some personal preventive measures plays an important role in achieving the balance between pandemic control and work resumption. Universal use of facemask [6], hand hygiene [7], and physical distancing (e.g., avoiding social/meal gathering and avoiding crowded places) [8] are strongly advocated by the World Health Organization (WHO) and have been implemented worldwide [9,10]. The effectiveness of these personal preventive measures crucially relied on compliance by the public [11]. Studies conducted in China, Australia and Thailand consistently supported that achieving a very high compliance (80-95%) with personal preventive measures were important to control the COVID-19 pandemic in these countries [5,9,12].

Understanding factors associated with personal preventive measures compliance is important to develop effective interventions. As interventions addressing factors at multiple levels are more likely to be successful in changing behaviour, we used the Socio-Ecological Model as the conceptual framework of our study [13]. This model considers determinants of health behaviors at individual-, interpersonal-, and social structural-level. Prior research on COVID-19 and other pandemics suggests the applicability of the Social-Ecological Model to inform behavioral change interventions in China. At the individual level, being knowledgeable about COVID-19 was associated with higher adoption of personal preventive measures among Hong Kong Chinese residents in the early phase of the pandemic [14]. Perceptions related to COVID-19 may also affect compliance with these personal preventive measures. For example, risk perceptions, perceived severity of the diseases, perceived effectiveness of the preventive measures, perceived preparedness of health systems and governments were associated with adoption of personal preventive measures during the SARS and H1N1 pandemics in China [15-18]. In addition, mental health status may be a particularly salient individual-level factor, as early studies in China have documented the high levels of psychological problems (e.g., stress, panic, depression and anxiety) triggered by the COVID-19 pandemic [19-21]. Having mental health problems were associated with lower adoption of personal preventive measures during COVID-19 pandemic [19]. At the interpersonal-level, the heightened level of governmental alerts was accompanied by widespread coverage of COVID-19 related information across different media, including television, newspapers, and social media [14]. Additionally, different media channels may have varying effects on personal preventive measures compliance. During the MERS outbreak, increased exposure to MERS-specific information through social media and interpersonal communication was associated with higher adoption of personal preventive measures. However, the association between exposure to information disseminated through traditional media (e.g., television, newspaper) and personal preventive measures was non-significant [22,23]. At the social structural-level, implementation of organizational preventive measures during work resumption may be

different across factories, which may also affect compliance with personal preventive measures.

To the best of our knowledge, there have been no study investigating self-reported compliance with personal preventive measures and associated factors among workers who resumed work during the COVID-19 pandemic. To address these gaps, this study investigated self-reported compliance with four personal preventive measures among a sample of factory workers in Shenzhen, China. We examined the effects of factors including socio-demographics, individual-level factors (knowledge, perception, and depressive symptoms), interpersonal-level factors (exposure to COVID-19 specific information through different media), and social structural-level factors (preventive measures implemented by the factories).

Methods

Study design

We conducted a cross-sectional closed online survey of 3035 factory workers in Shenzhen, China during March 1-14, 2020. Of the 13 million residents in Shenzhen in 2018, 65.1% were internal migrants and 34.3% were factory workers [24].

Participants and data collection

By March 1, 2020, one hundred factories in Shenzhen had resumed work. A stratified two-stage cluster sampling design was used to recruit study participants. First, fourteen factories were randomly selected by the research team. These factories manufactured electronic devices (n=10), watches (n=2), beverages (n=1), and biotechnology products (n=1). All full-time employees aged ≥18 years who had resumed work in these factories were invited to complete an online survey.

We developed an online questionnaire using Questionnaire Star, a commonly used online survey platform in China, the link to the questionnaire could be shared by WeChat. In addition to national guidelines, the Shenzhen government requested that each factory set up WeChat groups covering all employees as part of preparations for work resumption [2,3]. A designated coordinator

responsible for COVID-19 control in each factory facilitated the data collection. He/she posted the study information and the link to access the online self-administered questionnaire in the WeChat groups, and invited all eligible workers who had resumed work to participate. He/she also sent out reminders in the WeChat groups bi-weekly during the recruitment period. These designated coordinators did not participate in the actual survey. The coordinators and participants were asked not to disseminate the link to access the survey to people outside the 14 selected factories. Before starting the online survey, participants read a statement indicating that participation is voluntary, refusal would have no effect on them, the survey would not collect personal contacts or identification, and data would be kept strictly confidential and only be used for research purposes. Online informed consent was obtained. Each individual WeChat account was allowed to access the online questionnaire once to avoid duplicate responses. The survey had 93 items (about 15 items per page for 6 pages), which took about 20 minutes to complete. The Questionnaire Star performed completeness checks before the questionnaire was submitted. Participants were able to review and change their responses through a “Back” button. An e-coupon of 10RMB (1.3USD) was sent to participants upon completion. All data was stored in the online server of the Questionnaire Star and protected by password. Only the corresponding authors had the access to the database. Ethics approval was obtained from the Seventh Affiliated Hospital, Sun Yat-sen University (reference: KY-2020-005-001).

Measures

Design of the questionnaire

A panel consisting of two public health researchers, a health psychologist, two clinicians, a senior factory manager, and a factory worker was formed to develop the questionnaire used in the current study. The questionnaire was pilot tested among 10 factory workers to assess clarity and readability. These 10 workers did not participate in the actual survey. Based on participants’ comments, the panel revised and finalized the questionnaire.

Self-reported compliance with personal preventive measures in the past month

Participants were asked to report frequency of wearing facemasks in workplace and in other public settings (public places/transportation) in the past month (response categories: every time, often, sometimes, never). A composite variable was created representing self-reported consistent facemask wearing in any public places (referring to those who reported using a facemask every time both in the workplace and in other public settings). Types of facemask used and whether they had re-used facemasks were also collected. Participants also reported frequency of sanitizing hands using soaps/liquid soaps/alcohol-based hand rubs after returning from public spaces/touching public installations/equipment (e.g., handrails, escalator control panels or door knobs) (response categories: every time, often, sometimes, never), and whether they avoided social/meal gathering with people who do not living together and crowed places in the past month.

Background characteristics

Participants were asked to report on socio-demographics, such as age, gender, internal migrant status, highest education level, relationship status, monthly personal income, status as frontline workers or management staff, and type of factories they were working in.

Individual-level variables

Knowledge related to transmission route of COVID-19: A composite indicator variable was constructed by counting the number of correct responses to five knowledge items related to COVID-19 transmission routes (ranged from zero to five).

Perceptions related to COVID-19: Four scales were constructed for this study, including: 1) the 4-item Perceived Severity Scale, 2) the 4-item Perceived Effectiveness of Individual Preventive Measures Scale, 3) the 2-item Perceived Effectiveness of Governmental Preventive Measures Scale, and 4) the 2-item Perceived Preparedness Scale (preparedness of the health system and workplace).

The response categories for these scales were 1=disagree/ineffective, 2=neutral, and 3=agree/effective. The Cronbach's alpha of these four scales ranged from 0.70 to 0.92, and single factors were identified by exploratory factor analysis (EFA), explaining 77.3 to 80.9% of total variance. In addition, two single items measured perceived risk of contracting COVID-19 in the next three months (response categories: 1=low, 2=moderate, 3=high) and perceived effectiveness of preventive measures implemented by the factories (response categories: 1=very ineffective, 2=ineffective, 3=neutral, 4=effective, 5=very effective).

Depressive symptoms were measured by a validated Chinese version of the Patient Health Questionnaire (PHQ-9) [25]. The Cronbach's alpha of the PHQ-9 was 0.90; one factor was identified by EFA, explaining 54.7% of the total variance.

Interpersonal-level variables

Three items assessed daily average time (hours) of exposure to COVID-19 specific information through official media sources (television, newspapers, and online official media such as news apps or blogs and social media accounts of governmental organizations). The Exposure through Official Media Channels Scale was formed by summing up individual item scores. The Cronbach's alpha of the Exposure through Official Media Channels Scale was 0.71; one factor was identified by EFA, explaining 63.4% of the total variance. In addition, two single items measured daily average time of exposing to COVID-19 specific information through unofficial media channels (other people's blogs/ social media accounts), and direct interpersonal communication. Response categories for the aforementioned items were: 1=almost none, 2=less than 1 hour, 3=1-2 hours, 4=3-4 hours, and 5=>4 hours.

Social structural-level variables

Both the designated coordinators responsible for COVID-19 control within sampled factories, and the participants were asked to report whether their factory has implemented seven preventive measures advocated by the Shenzhen government [2,3]. A composite indicator variable was

constructed by counting the number of preventive measures implemented by the factory (ranging from 0 to 7). Items and scales measuring individual-, interpersonal-, and social structural-level variables were shown in multimedia Appendix 1.

Sample size planning

The target sample size was 3000. Given a statistical power of .80 and an alpha value of .05 and assuming the self-reported level of compliance with a personal preventive measure in the reference group (without a facilitating condition) to be 30-80%, the sample size could detect the smallest odds ratios of 1.23 between those with and without such facilitating condition (PASS 11.0, NCSS, Kaysville, United States). Assuming the response rate was 60%, 5000 workers needed to be invited. The median number of workers who had resumed working in the factories by the end of February 2020 was about 350. Therefore, the research team selected 14 factories.

Statistical analysis

Self-reported consistent facemask wearing in any public spaces, sanitizing hands every time after returning from public spaces or touching public installations/equipment, avoiding social/meal gathering with people who do not live together and avoiding crowed places were the dependent variables. Multilevel logistic regression models (level 1: factories, level 2: individual participants) were fit to analyze factors associated with the dependent variables. Random intercept models were used to allow the intercept of the regression model to vary across factories, which could account for intra-correlated nested data. Multilevel logistic regression models are commonly used in studies using cluster sampling methods [26]. Univariate two-level logistic models first assessed the significance of the association between each of the background characteristics and the dependent variables. Background characteristics with $p<0.05$ in univariate analysis were adjusted in the multivariate two-level logistic regression models. In addition, principal component analysis with varimax rotation was used to perform EFA [27]. SPSS version 23.0 for Windows (SPSS, Inc, Chicago, IL, the United States) was used for data analysis, with $p<0.05$ considered statistically

significant.

Results

Background characteristics

Out of 4158 workers (between 90 and 835 across different factories) who had resumed work in these factories on March 1, 2020, 3035 completed the online survey (between 56 and 635 across different factories). The overall response rate was 73.0%. Over half of the participants were younger than 30 years old (51.1%, n=1552), male (53.1%, n=1612), internal migrants (97.4%, n=2056), married (59.7%, n=1812), did not receive tertiary education (66%, n=2004), with monthly income level lower than 5,000RMB (714USD) (50.8%, n=1538), were front-line workers (60.9%, n=1847), and were working in electronic devices manufacturers (77.5%, n=2353). (Table 1)

Table 1 Background characteristics of the participants (n=3035)

	N	%
Age group (years)		
18-25	653	21.5
26-30	899	29.6
31-40	1195	39.4
>40	288	9.5
Gender		
Male	1612	53.1
Female	1423	46.9
Internal migrants		
Yes	2956	97.4
No	79	2.6
Relationships status		
Currently single	878	28.9
Having a stable boyfriend/girlfriend	345	11.4
Married	1812	59.7
Highest education level attained		
Junior high or below	1163	38.3
Senior high or equivalent	841	27.7
College or university	895	29.5
Postgraduate	136	4.5
Monthly personal income (RMB)		
<3,000	175	5.9
3,000-4,999	1363	44.9
5,000-6,999	763	25.1
7,000-9,999	327	10.8
≥10,000	403	13.3
Type of work		

Frontline workers	1847	60.9
Management staff	1188	39.1
Type of factories they were working in		
Electronic devices manufacturers	2353	77.5
Watchmaking factories	307	10.1
Beverages manufacturers	191	6.3
Biotechnology products manufacturers	184	6.1

Self-reported compliance with personal preventive measures in the past month

In the past month, 96.8% (n=2938) and 98.7% (n=2996) of participants reported wearing a facemask every time in the workplace and in other public settings, respectively. Over 95% (n=2904) reported consistent facemask wearing in any public places. Non-surgical grade respirators were most commonly used by participants (68.3%, n=2073) and 19.8% (n=601) re-used facemasks. Self-reported sanitizing hands (70.9%, n=2152), avoiding social/meal gathering (73.3%, n=2225) and avoiding crowed places (65.8%, n=1997) were less common. (Table 2)

Table 2 Self-reported compliance with personal preventive measures and variables related to COVID-19

	n (%)	Mean (SD)
Self-reported compliance with personal preventive measures in the past month		
Frequency of face mask wearing in workplace		
Every time	2996 (98.7)	
Often	33 (1.1)	
Sometimes	3 (0.1)	
Never	3 (0.1)	
Frequency of face mask wearing in public places/transportation other than workplace		
Every time	2938 (96.8)	
Often	91 (3.0)	
Sometimes	3 (0.1)	
Never	3 (0.1)	
Self-reported consistent face mask wearing in any public spaces		
No	131 (4.3)	
Yes	2904 (95.7)	
Type of face mask used by the participants		
Surgical masks	1360 (44.8)	
Non-surgical grade respirators	2073 (68.3)	
N-95 masks	801 (26.4)	
Cloth masks	161 (5.3)	

Re-using face mask		
No	2434 (80.2)	
Yes	601 (19.8)	
Self-reported sanitizing hands (using soaps, liquid soaps or alcohol-based sanitizer) after returning from public spaces or touching public installation		
Every time	2152 (70.9)	
Often	419 (16.8)	
Sometimes	243 (8.0)	
Never	131 (4.3)	
Self-reported avoiding social/meal gathering with other people who do not live together		
No	810 (26.7)	
Yes	2225 (73.3)	
Self-reported avoiding crowed places		
No	1056 (34.8)	
Yes	1997 (65.8)	
Individual-level variables		
Knowledge about transmission route of COVID-19		
Whether COVID-19 can be transmitted through (% Yes)		
Droplets	2871 (94.6)	
Touching contaminated objects	2707 (89.2)	
Direct contact with wildlife	2625 (86.5)	
Fecal-borne	2364 (77.9)	
Asymptomatic patients	2319 (76.4)	
Number of correct responses to COVID-19 transmission route		4.2 (1.3)
0	131 (4.3)	
1	49 (1.6)	
2	94 (3.1)	
3	264 (8.7)	
4	634 (20.9)	
5	1863 (61.4)	
Perceptions related to COVID-19		
Perceived one's risk of contracting COVID-19 (% high)	36 (1.2)	1.3 (0.5)
Perceived consequences of COVID-19 (% agree)		
Result in permanent bodily damage among infected people	1226 (40.4)	
High mortality rate of infected people	1687 (55.6)	
Lack of effective treatment	1687 (55.6)	
Lack of effective vaccines for prevention	1772 (58.4)	
Perceived Severity Scale [1]		9.1 (2.1)
Perceived effectiveness of individual-level preventive measures (% effective)		
Wearing facemasks	2407 (79.3)	

Sanitizing hands frequently	2464 (81.2)	
Household disinfection	2331 (76.8)	
Avoiding gathering	2722 (89.7)	
Perceived Effectiveness of Individual Preventive Measures Scale [2]		11.1 (1.8)
Perceived effectiveness of preventive measures taken by the factories (% effective/very effective)	2525 (83.2)	4.2 (1.0)
Perceived effectiveness of governmental preventive measures (% effective)		
Closure of public spaces (e.g., restaurants, theatres, etc.)	2610 (86.0)	
Restricting people coming in/out of Shenzhen	2583 (85.1)	
Perceived Effectiveness of Governmental Preventive Measures Scale [3]		5.6 (0.9)
Perceived organizational preparedness for COVID-19 outbreak after work resumption (%agree)		
The factory in which you are working is well-prepared for COVID-19 outbreak after work resumption	2586 (85.2)	
Medical system in Shenzhen is well-prepared for COVID-19 outbreak after work resumption	2297 (75.7)	
Perceived Preparedness Scale [4]		5.6 (0.8)
Mental health status		
PHQ-9 [5]		7.5 (2.5)
Probable depression (PHQ-9 score ≥10)	192 (6.4)	
Interpersonal-level variables		
Daily average time (hours) of exposing to COVID-19-related information through different official media channels		
Television		
Almost none	613 (20.2)	
Less than 1 hour	1408 (46.4)	
1-2 hours	607 (20.0)	
3-4 hours	146 (4.8)	
>4 hours	258 (8.5)	
Newspaper		
Almost none	1627 (53.6)	
Less than 1 hour	907 (29.9)	
1-2 hours	294 (9.7)	
3-4 hours	79 (2.6)	
>4 hours	127 (4.2)	
Online official medias (news apps, blogs of governmental organizations)		
Almost none	134 (4.4)	
Less than 1 hour	1263 (41.6)	
1-2 hours	911 (30.0)	

3-4 hours	258 (8.5)	
>4 hours	469 (15.5)	
Exposure through Official Media Channels Scale [6]		7.0 (2.6)
Daily average time (hours) of exposing to COVID-19-related information through unofficial media channels (e.g., other people's blogs)		2.4 (1.1)
Almost none	543 (17.9)	
Less than 1 hour	1436 (47.3)	
1-2 hours	571 (18.8)	
3-4 hours	185 (6.1)	
>4 hours	300 (9.9)	
Daily average time (hours) of exposing to COVID-19-related information through face-to-face communication		1.9 (1.0)
Almost none	1269 (41.8)	
Less than 1 hour	1260 (41.5)	
1-2 hours	310 (10.2)	
3-4 hours	76 (2.5)	
>4 hours	121 (4.0)	
Social structural-level variables		
Preventive measures implemented by the factory in which you are working (among 3035 factory workers) (% Yes)		
Mandatory 14-day quarantine for employees returning from high-risk area	2901 (95.6)	
Prohibiting non-employees entering workplaces	2664 (87.8)	
Taking body temperature and sanitizing hands for all employees entering the workplace	2980 (98.2)	
Providing facemasks to all employees	2999 (98.8)	
Requiring employees to wear facemasks in workplace	3023 (99.6)	
Frequent workplace disinfection	2986 (98.4)	
Setting up partitions in factory canteens	2838 (93.5)	
Number of preventive measures implemented by the factory		6.7 (0.7)
Preventive measures implemented by the factory in which you are working (among 14 designated persons responsible for COVID-19 control) (% Yes)		
Mandatory 14-day quarantine for employees returning from high-risk area	14 (100.0)	
Prohibiting non-employees entering workplaces	14 (100.0)	
Taking body temperature and sanitizing hands for all employees entering the workplace	14 (100.0)	
Providing facemasks to all employees	14 (100.0)	
Requiring employees to wear facemasks in workplace	14 (100.0)	
Frequent workplace disinfection	14 (100.0)	
Setting up partitions in factory canteens	14 (100.0)	

[1] Perceived Severity Scale, 4 items, Cronbach alpha: 0.70, 1 factor was identified by exploratory

factor analysis, explaining for 77.3% of total variance
[2] Perceived Effectiveness of Individual-level Preventive Measures Scale, 4 items, Cronbach alpha: 0.92, 1 factor was identified by exploratory factor analysis, explaining for 80.9% of total variance
[3] Perceived Effectiveness of Structural-level Preventive Measures Scale, 2 items, Cronbach alpha: 0.85
[4] Perceived Organizational Preparedness Scale, 2 items, Cronbach alpha: 0.76
[5] PHQ-9 Scale, 9 items, Cronbach alpha: 0.90, 1 factor was identified by exploratory factor analysis, explaining for 54.7% of total variance
[6] Exposure through Official Media Channels Scale, 3 items, Cronbach alpha: 0.71, 1 factor was identified by exploratory factor analysis, explaining for 63.4% of total variance

Factors associated with self-reported compliance with personal preventive measures in the past month

In the univariate multilevel logistic regression analysis, age, gender, education level, monthly personal income, status as frontline workers or management staff and type of factories they were working in were significantly associated with self-reported compliance with one or more types of personal preventive measures (Table 3).

Table 3 Associations between background characteristics and self-reported compliance with different personal preventive measures (n=3035)

	Self-reported consistent face mask wearing in any public spaces	Self-reported sanitizing hands every time after returning from public spaces or touching installations	Self-reported avoiding social/meal gathering with people who do not live together	Self-reported avoiding crowed places
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age group (years)				
18-25	1.0	1.0	1.0	1.0
26-30	1.31 (0.77, 2.20)	1.17 (0.94, 1.46)	1.10 (0.87, 1.39)	1.16 (0.93, 1.44)
31-40	1.29 (0.78, 2.12)	1.22 (0.98, 1.52)	1.23 (0.98, 1.54)	1.27 (1.02, 1.57)[b]
>40	0.51 (0.29, 0.91)[a]	1.34 (0.95, 1.88)	1.04 (0.75, 1.44)	1.18 (0.86, 1.60)
Gender				
Male	1.0	1.0	1.0	1.0
Female	0.83 (0.58, 1.19)	1.20 (1.01, 1.41)[a]	0.71 (0.60, 0.84)[c]	0.73 (0.62, 0.85)[c]
Internal migrants				
Yes	1.0	1.0	1.0	1.0
No	0.86	1.55	1.29	1.40

	(0.33, 2.26)	(0.87, 2.79)	(0.72, 2.31)	(0.81, 2.43)
Relationships status				
Currently single	1.0	1.0	1.0	1.0
Having a stable boyfriend/girlfriend	1.28 (0.66, 2.48)	1.04 (0.80, 1.36)	1.11 (0.83, 1.48)	1.13 (0.85, 1.48)
Married	1.10 (0.73, 1.64)	1.30 (1.08, 1.57)[b]	1.16 (0.95, 1.40)	1.11 (0.93, 1.33)
Highest education level attained				
Junior high or below	1.0	1.0	1.0	1.0
Senior high or equivalent	2.47 (1.53, 4.01)[c]	1.12 (0.91, 1.38)	1.64 (1.35, 2.00)[c]	1.77 (1.47, 2.13)[c]
College or university	2.80 (1.64, 4.77)[c]	0.94 (0.75, 1.18)	3.38 (2.66, 4.29)[c]	4.63 (3.70, 5.80)[c]
Postgraduate	3.69 (1.07, 12.71)[a]	1.19 (0.78, 1.82)	28.58 (8.94, 91.36)[c]	11.50 (6.04, 21.87)[c]
Monthly personal income (RMB)				
<3,000	1.0	1.0	1.0	1.0
3,000-4,999	0.84 (0.41, 1.73)	1.16 (0.83, 1.64)	1.27 (0.92, 1.75)	1.40 (1.02, 1.93)[a]
5,000-6,999	1.82 (0.81, 4.07)	1.25 (0.87, 1.79)	1.71 (1.21, 2.42)[b]	2.16 (1.54, 3.03)[c]
7,000-9,999	3.58 (1.21, 10.59)[a]	0.89 (0.60, 1.34)	3.84 (2.46, 5.99)[c]	4.62 (3.05, 7.02)[c]
≥10,000	2.04 (0.81, 5.10)	1.32 (0.89, 1.97)	7.36 (4.54, 11.92)[c]	8.26 (5.32, 12.82)[c]
Type of work				
Frontline workers	1.0	1.0	1.0	1.0
Management staff	1.69 (1.13, 2.52)[a]	1.04 (0.88, 1.23)	2.37 (1.96, 2.86)[c]	2.65 (2.22, 3.15)[c]
Type of factories they were working in				
Electronic devices manufacturers	1.0	1.0	1.0	1.0
Watchmaking factories	2.06 (0.90, 4.76)	1.94 (1.44, 2.61)[c]	0.70 (0.55, 0.91)[b]	0.63 (0.50, 0.80)[c]
Beverages manufacturers	0.45 (0.26, 0.78)[b]	0.94 (0.69, 1.29)	0.94 (0.67, 1.30)	0.76 (0.56, 1.02)
Biotechnology products manufacturers	0.40 (0.24, 0.69)[b]	2.15 (1.45, 3.17)[c]	1.85 (1.24, 2.76)[c]	2.30 (1.57, 3.37)[c]

OR: crude odds ratios obtained from two-level logistic regression models (level 1: factories, level 2: individual participants)
CI: confidence interval
[a] $p<0.05$, [b] $p<0.01$, [c] $p<0.001$

After adjusting for these significant background characteristics, knowledge about

transmission routes of COVID-19 (adjusted odds ratio [AOR]: 1.16-1.29), perceived risk of contracting COVID-19 (AOR: 0.58-0.85), perceived effectiveness of individual (AOR: 1.05-1.09) and governmental preventive measures (AOR: 1.14-1.21), and number of preventive measures implemented by the factory (AOR: 1.30-1.63) were associated with self-reported compliance with all four personal preventive measures. Perceived preparedness to potential outbreak after work resumption was associated with self-reported compliance with all personal preventive measures (AOR: 1.10-1.50) with the exception of consistent face mask wearing. Perceived severity of COVID-19 was associated with higher self-reported compliance with two physical distancing measures (AOR: 1.05 & 1.07) but not with consistent face mask wearing or sanitizing hands. In addition, perceived effectiveness of preventive measures implemented by the factory (AOR: 1.30), depressive symptoms (AOR: 0.87), and exposure to COVID-19 specific information through official media channels (AOR: 1.08) and face-to-face communication (AOR: 0.90) were associated with self-reported sanitizing hands but not with other personal preventive measures. (Table 4)

Table 4 Factors associated with self-reported compliance with different personal preventive measures (n=3035)

	Self-reported consistent face mask wearing in any public spaces	Self-reported sanitizing hands every time after returning from public spaces or touching installations	Self-reported avoiding social/meal gathering with people who do not live together	Self-reported avoiding crowed places
	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)
Individual-level variables				
Knowledge and perceptions				
Knowledge about transmission route of COVID-19	1.21 (1.08, 1.36)[c]	1.16 (1.10, 1.24)[c]	1.18 (1.11, 1.26)[c]	1.29 (1.21, 1.37)[c]
Perceived one's risk of contracting COVID-19	0.71 (0.50, 0.99)[a]	0.58 (0.50, 0.68)[c]	0.85 (0.72, 0.99)[a]	0.81 (0.69, 0.95)[b]
Perceived Severity Scale	1.03 (0.95, 1.12)	1.03 (0.99, 1.07)	1.05 (1.01, 1.09)[a]	1.07 (1.03, 1.11)[b]

Perceived Effectiveness of Individual Preventive Measures Scale	1.08 (1.00, 1.18)[a]	1.09 (1.04, 1.13)[c]	1.06 (1.01, 1.11)[a]	1.05 (1.00, 1.10)[a]
Perceived effectiveness of preventive measures taken by the factories	1.00 (0.83, 1.20)	1.30 (1.20, 1.41)[c]	1.01 (0.92, 1.10)	1.00 (0.92. 1.09)
Perceived Effectiveness of Governmental Preventive Measures Scale	1.21 (1.02, 1.42)[a]	1.14 (1.04, 1.24)[b]	1.15 (1.05, 1.26)[b]	1.14 (1.04, 1.25)[b]
Perceived Organizational Preparedness Scale	0.92 (0.72, 1.16)	1.50 (1.36, 1.64)[c]	1.12 (1.02, 1.24)[a]	1.10 (1.00, 1.21)[a]
Mental health status				
PHQ-9	1.05 (0.98, 1.13)	0.87 (0.85, 0.90)c	0.97 (0.93, 1.01)	0.99 (0.96, 1.03)
Interpersonal-level variables				
Exposure Through Official Media Channels Scale	1.02 (0.96, 1.10)	1.08 (1.04, 1.11)[c]	1.00 (0.97, 1.03)	1.00 (0.97, 1.03)
Exposure through unofficial media channels	1.03 (0.88, 1.21)	1.07 (0.99, 1.15)	0.99 (0.92, 1.07)	0.99 (0.92, 1.06)
Exposure through face-to-face communication	1.12 (0.92, 1.37)	0.90 (0.83, 0.98)[a]	1.00 (0.92, 1.09)	1.02 (0.94, 1.10)
Social structural-level variables				
Number of preventive measures implemented by the factory	1.30 (1.08, 1.57)[b]	1.63 (1.45, 1.84)[c]	1.34 (1.19, 1.51)[c]	1.47 (1.30, 1.66)[c]

AOR: adjusted odds ratios, background characteristics with $p<0.05$ in univariate analysis were adjusted in the multivariate two-level logistic regression models (level 1: factories, level 2: individual participants)

CI: confidence interval

[a] $p<0.05$, [b] $p<0.01$, [c] $p<0.001$

Discussion

Recent study suggested that physical distancing and population behavioral change that have a less disruptive economic impact than total lockdown could meaningfully control COVID-19 [28]. Our study showed that both factories and workers in Shenzhen are well prepared for work resumption. The prevalence of consistent facemask wearing surged from 60% in early phase of COVID-19 outbreak (February, 2020) to over 95% in our study [21]. Consistent facemask wearing is especially important in workplaces such as factories where physical distancing cannot be guaranteed. It is also encouraging to see the all sampled factories are proactively implementing all preventive measures advocated by the government [2,3]. These efforts by factories and workers may contribute to the effective COVID-19 control after work resumption in China [1].

However, this study highlighted issues related to personal preventive measures that should be addressed by future interventions. First, many workers used non-surgical grade respirators or even cloth masks, and about 20% had re-used facemasks in the past month. It is understandable as surgical grade masks, which provide the highest level of protection against COVID-19, were in limited supply in the early phase of outbreak in China. To address the supply issue, China has rapidly increased its facemask production capacity. Second, there are needs to improve hand hygiene and physical distancing. Despite WHO recommendations on hand hygiene [7], only about 70% of participants always sanitized their hands. There are some possible reasons to explain the relatively low adoption of this preventive measure. The importance of hand hygiene might be less emphasized than consistent facemask wearing in China during the outbreak. Moreover, there might be a lack of appropriate places for workers to sanitize their hands. Only 70% of factory workers avoided social/meal gathering or crowded places in the past month. Most Chinese cities enforced community lockdown in the early phase of outbreak. There will be relaxation of some voluntary physical distancing measures when lockdown is lifted. Without strengthening of these measures, local infection are likely to occur.

Our findings provided empirical insights to inform intervention development, and suggest the need to tailor interventions to specific groups. Male factory workers were less likely to sanitize hands frequently but were more likely to comply with physical distancing measures. Promotion efforts should account for gender differences. More attention should be given to workers with lower education level, as they showed lower compliance with consistent facemask wearing and physical distancing measures compared to workers with higher levels of education. Health communication messages should be at the appropriate literacy levels and straightforward. Management staff performed better in complying with personal preventive measures than frontline workers. These results may be due to the fact that unlike management staff who primarily work in an office, frontline workers may face barriers related to their duties and working environment. It is important for factories to identify and address these barriers, and allow workers to take necessary precautions. Moreover, level of self-reported compliance with personal preventive measures varied across different types of factories. Different composition of workers might explain some of these differences. For example, as compared to electronic devices manufacturers, workers in watchmaking factories reported higher compliance to hand hygiene but performed worse in physical distancing. Such difference might due to higher proportion of female workers (over 70% in this study) in watchmaking factories as compared to that of electronic devices manufacturers (about 50%). Therefore, tailored interventions should be given to different type of factories. Interventions targeting watchmaking factories should focus on physical distancing, while those targeting beverages/biotechnology product manufacturers should emphasize consistent facemask wearing.

At social structural-level, preventive measures implemented by the sampled factories played important roles in COVID-19 prevention, as knowing more preventive measures implemented by the factories were positively associated with compliance with all four personal preventive measures. Some of these measures directly increase access to facemask and facilitate physical distancing (e.g., setting up partitions in factory canteens). Moreover, factories could cultivate widely shared

organizational norms in order to facilitate behavioral changes among the workers when implementing these preventive measures [29]. Factories should disseminate these measures to all workers and monitor the implementation of these preventive measures regularly during the pandemic.

Consistent with findings of previous studies, knowledge and perceptions related to COVID-19 had a strong influence on compliance with personal preventive measures [15-18]. Most workers were knowledgeable about transmission routes of COVID-19. New findings such as risk of transmission among asymptomatic patients or the possible faecal-oral transmission should be disseminated to the workers. As compared to results from other studies during the early phase of the outbreak, fewer participants perceived a high risk of contracting COVID-19, probably due to the initial control of the pandemic in China [14]. One possible explanation for the observed negative association between risk perception and compliance may be that those who were not able to comply with these behaviors would perceive higher risk.

Increasing knowledge and perceived severity of COVID-19, and disseminating the efficacy of individual and governmental preventive measures may be useful strategies in future programs. To enhance compliance with these preventive measures, the government and the factories should make their preparedness plan transparent to factory workers. The significant association between perceived effectiveness of preventive measures implemented by the factories and sanitizing hands seems to support our speculation that facilities for sanitizing hands in workplace may be an important determinant. Strategically placing hand sanitizer in high traffic locations throughout the workplace should be considered. Non-compliance with personal preventive measures might be used as a negative coping response to depressive symptoms [30]. Providing psychological support to workers during the work resumption is also useful to enhance their compliance with personal preventive measures.

We also found that exposure to different types of media had differing effects on compliance

with personal preventive measures, as our results showed that media exposure only influenced hand hygiene. Moreover, exposure through official media channels had positive impact on hand hygiene, while exposure through unofficial media channels and face-to-face communication had null or even negative impact on the same behavior. Previous studies suggested that the more people read newspapers and watched TV about MERS, the more knowledge they acquired about the disease and prevention strategies [22,23]. Compared to official media channels which mainly report information verified by expert sources, unofficial online media channels and face-to-face communication can not only disseminate knowledge but also false/unverified information during the crisis. The null effects of exposure through unofficial online media channels may have resulted from the conflicting contents. Consequences of misinformation could be long-lasting and should not be underestimated in health crisis management [31]. It is speculated that sanitizing hands was not only determined by individual perceptions, but also by peers' practices. Since sanitizing hands was not highly prevalent, factory workers might discourage others to perform such behavior during face-to-face communication. Future studies should verify our speculation with a robust examination.

Our study was one of the first studies targeting factory workers at the beginning of work resumption during COVID-19 pandemic. It used the Socio-Ecological Model as a theoretical framework and examined potential associated factors at multiple levels. This study provided evidence to inform multilevel programs to strengthen compliance with personal preventive measures among factory workers. Currently, many countries are in the early stage of work resumption and trying to achieve the balance of economic reactivation and COVID-19 pandemic control, our findings have some reference values to these countries.

However, this study had some limitations. First, policies and guidelines related to COVID-19 control have been updating rapidly in response to the quickly changing pandemic. Such changes in national policies/guidelines have strong influence on self-reported compliance to personal preventive measures. For example, the National Health Commission of China updated the requirement of

facemask wearing in workplace on March 18, 2020, which stated that facemask wearing was required in workplace only when people are in close contact with others (<1 meter). Therefore, our findings were most applicable to early phase of COVID-19 outbreak when strict measures were enforced, and had limited implication in the current situation of China. However, the risk of another wave of outbreak still existed in China. In case of another wave of outbreak, some strict control measures are likely to be implemented again. Our findings could inform effective interventions facilitating the implementation of such strict control measures. Second, we only included factory workers in one Chinese city. Generalization should be made cautiously to individuals working in other types of enterprises or to other places in China. Third, since this study was anonymous and did not collect participants' personal contact or identification, we were not able to collect information of workers who refused to participate in the study. Factory workers who refused to complete the survey might have different characteristics as compared to the participants. Selection bias existed. Our response rate was relatively high (73.0%) as compared to other online surveys of similar topics [19,20]. Fourth, data were self-reported and verification was not feasible. Recall bias might exist. Participants might also over-report their compliance with personal preventive measures due to social desirability. Fifth, most items and scales used in this study were self-constructed based on those from previous studies on SARS and H1N1 in China [15-18]. The internal reliability for these scales was acceptable but these scales may require external validation. Sixth, it was a limitation that we arbitrarily chose the cut-off for different age groups. Moreover, some behavioral factors influence personal preventive behaviors during COVID-19 were not considered by this study, such as previous experiences with pandemics, concerns related to personal protection equipment supply, resource constraint, and comfort of adopting these preventive measures [32]. National guidelines emphasize that maintaining good ventilation in workplace is an essential strategy for COVID-19 control [33]. Failure to consider ventilation in workplace was another limitation of this study. Furthermore, causality could not be established as this was a cross-sectional study.

In sum, factory workers in China self-reported a very high level of compliance with consistent facemask wearing at the beginning of work resumption. However, there is need to strengthen hand hygiene and physical distancing. Strategically placing hand sanitizer in workplace should be considered. Future programs should address multiple-level factors associated with these preventive measures. Our findings have some reference values to other countries that are at the early stage of work resumption.

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Authors' Contributions

Yihang Pan and Yuan Fang contributed equally as first authors. Jinqiu Yuan, Zixin Wang, and Yulong He contributed equally as corresponding authors.

Multimedia Appendix 1: Items measuring individual-, interpersonal-, and socio-structural-level variables in both English and Chinese.

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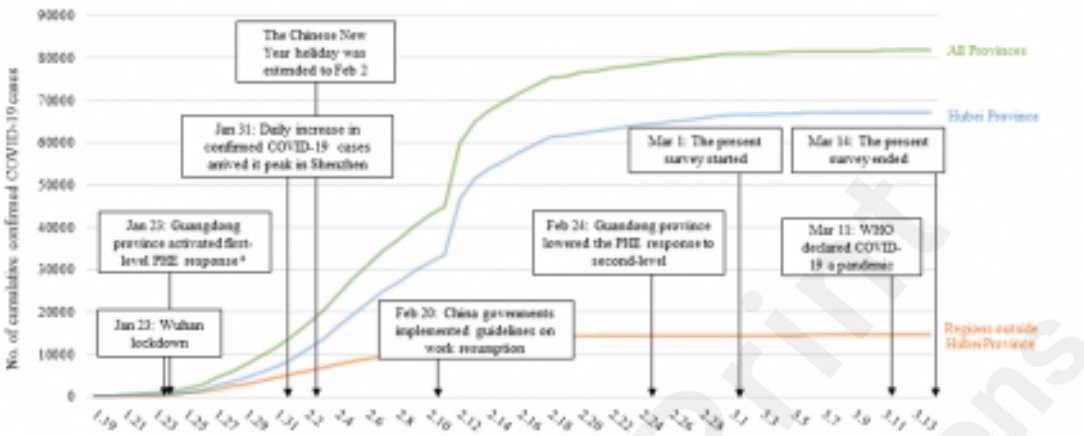
Supplementary Files

Figures

Background of the present survey including the trend of cumulative confirmed COVID-19 cases in mainland China and critical responses to COVID-19.



PHE denotes public health emergency.
a. Shenzhen is a city of Guangdong Province.

Multimedia Appendixes

Items measuring individual-, interpersonal-, and social structural-level variables in both English and Chinese.
URL: https://asset.jmir.pub/assets/c7bd827d063d979c2b5e3537ab6d994f.docx