Circulation: Cardiovascular Quality and Outcomes

ORIGINAL ARTICLE

Changes in Home Blood Pressure Monitored Among Elderly Patients With Hypertension During the COVID-19 Outbreak

A Longitudinal Study in China Leveraging a Smartphone-Based Application

BACKGROUND: The coronavirus disease 2019 (COVID-19) pandemic has impacted clinical care worldwide. Evidence of how this health crisis affected common conditions like blood pressure (BP) control is uncertain.

METHODS: We used longitudinal BP data from an ongoing randomized clinical trial to examine variations in home BP monitored via a smartphone-based application (app) in a total of 7394 elderly patients with hypertension aged 60 to 80 years stratified by their location in Wuhan (n=283) compared with other provinces of China (n=7111). Change in morning systolic BP (SBP) was analyzed for 5 30-day phases during the pandemic, including preepidemic (October 21 to November 20, 2019), incubation (November 21 to December 20, 2019), developing (December 21, 2019 to January 20, 2020), outbreak (January 21 to February 20, 2020), and plateau (February 21 to March 21, 2020).

RESULTS: Compared with non-Wuhan areas of China, average morning SBP (adjusted for age, sex, body mass index) in Wuhan patients was significantly higher during the epidemic growth phases, which returned to normal at the plateau. Between-group differences in ΔSBP were +2.5, +3.0, and +2.1 mm Hg at the incubation, developing, and outbreak phases of COVID-19 ($P<0.001$), respectively. Sensitivity analysis showed a similar trend in trajectory pattern of SBP in both the intensive and standard BP control groups of the trial. Patients in Wuhan also had an increased regimen change in antihypertensive drugs during the outbreak compared with non-Wuhan patients. Expectedly, Wuhan patients were more likely to check their BP via the app, while doctors were less likely to monitor the app for BP control during the pandemic.

CONCLUSIONS: Our data demonstrate that the COVID-19 pandemic was associated with a short-term increase in morning SBP among elderly patients with hypertension in Wuhan but not other parts of China. Further study will be needed to understand if these findings extended to other parts of the world substantially affected by the virus.

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Key Words: coronavirus disease 2019 ■ home blood pressure ■ hypertension ■ pandemic ■ smartphone-based application

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WHAT IS KNOWN

- A coronavirus disease 2019 (COVID-19) pandemic has broken out around the world, and patients with hypertension may experience large fluctuations in blood pressure (BP); however, there is lack of large-scale evidence how this special health crisis affects BP control.
- Smartphone-based telemonitoring of home BP may be effective in improving hypertension management, particularly among patients with chronic disease at high risk.

WHAT THE STUDY ADDS

- In this large longitudinal cohort leveraging a smartphone-based monitoring of home BP, our data demonstrated that the COVID-19 pandemic can cause a significant short-term increase of morning BP among elderly patients with hypertension comparable to before the COVID-19 outbreak.
- Patients in Wuhan (the epidemic center of China) had higher average morning SBP level and SBP variability compared with other provinces of China during the epidemic growth phase; and expectedly, patients were more likely to check their BP via the app platform while doctors were less likely to monitor the app for BP control during the pandemic.
- Use of smartphone-based app is helpful to assist patients in BP control during the pandemic, indicating its potential role in public health benefits.

Hypertension is an important global health challenge, and its prevalence increases with age, affecting >50% of elderly people aged ≥60 years.[1,2] However, blood pressure (BP) control has been a difficult problem. Home BP monitoring plays an important role in solving this problem, which has been recommended as an adjunct to office BP diagnosis by the guidelines.[3] Especially in recent years, with the innovation of remote technology, home BP management through internet telemedicine system has a more positive effect on BP control.[4–6]

During 2020, the coronavirus disease 2019 (COVID-19) pandemic broke out around the world and has led to >1 million deaths worldwide.[7] It has been reported that among people infected with COVID-19, there is a higher mortality rate for those with coexisting disorders, including hypertension.[8] Furthermore, along with the appearance of psychological stress such as anxiety, depression, or other negative emotions, patients with hypertension may experience large fluctuations in blood pressure. It is critical to manage BP effectively during the COVD-19 pandemic; however, there is a lack of evidence from large-scale prospective cohort studies as to whether BP control has worsened.

In China, the first COVID-19 case was detected and reported in Wuhan in early December 2019, the outbreak started in early January 2020, and then rapidly spread countrywide and reached the peak of the infection in February. Under the emergent actions taken by the Chinese government, such as traffic restriction and building the FangCang shelter hospitals, the pandemic has been under control in late March, 2020.[9] In this study, we used a randomized clinical trial of BP management leveraging a smartphone-based application (app) to examine changes in home BP comparing participants in Wuhan China to other provinces of China before and during the COVID-19 outbreak.

METHODS

Availability of Data

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Classification of COVID-19 Epidemic Period

In this study, 5 30-day phases were classified on the basis of dynamics of the COVID-19 pandemic and actions taken by the Chinese government,[10,11] including the preepidemic phase as the reference (October 21 to November 20, 2019), incubation phase (November 21 to December 20, 2019), developing phase (December 21, 2019 to January 20, 2020), outbreak phase (January 21 to February 20, 2020), and plateau phase (February 21 to March 21, 2020). The details were described in the Data Supplement. The timeline of the COVID-19 outbreak was illustrated in Figure I in the Data Supplement.

Study Participants

The participants were from the STEP (Strategy of Blood Pressure Intervention in the Elderly Hypertensive Patients) study, an ongoing clinical trial of BP management in elderly patients with hypertension in China.[12] Briefly, STEP is a multicenter, randomized controlled trial, and a total of 8511 patients with essential hypertension aged 60 to 80 years has been enrolled from January 10, 2017 to December 31, 2017 and followed up every 3 months. The inclusion and exclusion criteria as well as BP intervention were described in Methods in the Data Supplement. The 42 participating hospitals were listed in Table I in the Data Supplement, and geographic map was shown in Figure II in the Data Supplement. This study has been approved by the Ethics Committee of FuWai Hospital and collaborating clinic centers. All participants provided written informed consent.

All participants were provided with the same validated Omron automatic BP monitor (HEM-9200T, Omron Healthcare, Kyoto, Japan) that had a blue-tooth function to allow for uploading the home BP readings to data center via a smartphone-based app platform. In the present study, longitudinal data of home morning BP were extracted to examine how the recent COVID-19 outbreak in Wuhan and other provinces of China affected the BP control. A total of 1117 patients were excluded because a lack of BP measurement during the pandemic, and 7394 patients were included for analyzing the BP changes (n=283 in Wuhan and n=7111 in non-Wuhan areas; Figure 1). Among the 1117 patients who were excluded, 4 patients in non-Wuhan areas died during the pandemic, including 3 deaths from cardiovascular events and

1 death from cancer; and no patients died in Wuhan during this period. All included patients were required to have a BP measurement at each phase from the preepidemic to the plateau period (October 21, 2019 to March 21, 2020). There was modest difference in age between the excluded and included patients, and the excluded were older than the included (69.4 versus 68.6 years; Table II in the Data Supplement).

Assessment of Covariates

All participants completed a standardized questionnaire at baseline survey, and assessment of clinical characteristics were detailed in Methods in the Data Supplement. Antihypertensive medications used in this study (including calcium channel blocker, angiotensin receptor blocker, β-blocker, and hydrochlorothiazides) were collected during the follow-up period, and regimen change was considered if a patient increased or decreased dose of antihypertensive agent, or received an additional agent, or switching to a different agent class.

Home Blood Pressure Measurements and Variability

The app platform of this study was designed to automatically sync with home BP of patients and to send reminders of WeChat to patients if BP was not measured regularly and transmitted to the data center. Both doctors and patients can track daily home BP readings and graphical trends in BP change via the app during the follow-up period. A monthly report about BP surveillance is generated and sent to doctors for improving the efficiency of BP control. The app also designs a module of interactive communications between patients and doctors regarding BP control and medicine treatment. For BP measurement, patients were required to rest for at least 5 minutes in a seated position, and BP was measured 3× at least 1 minute apart. All patients were required to measure their home BP at least 1 to 3 days per week. Details are shown in Methods in the Data Supplement.

Intraindividual reading-to-reading variability of BP was evaluated by the coefficient of variation of BP (SD [SD]/mean×100%). Coefficient of variation is derived from the ratio of SD to the mean and considered as an applicable index in variability studies because it is less influenced by the individual's BP level.

Statistical Analysis

Clinical characteristics of participants were compared between groups by χ^2 tests for categorical variables (expressed as numbers [percentages]) and *t* tests for quantitative variables (expressed as mean±SD). The Mann-Whitney *U* test was used for triglycerides (expressed as median [interquartile range]) due to skewed distribution.

In this study, morning SBP data were presented as mean (95% CI). Linear mixed models were used to compare morning BP at the individual-level at each phase of epidemic between patients in Wuhan and non-Wuhan areas, with random intercepts to account for repeated measurements within the same patients. These models were adjusted for age, sex, and body mass index (BMI). Time (5 phases of the COVID-19 period) and region group (in Wuhan or non-Wuhan areas) were fitted as fixed effects, and an interaction term between time and region group was included in the model. For comparing the between-group difference in the change of average morning BP between Wuhan and non-Wuhan areas at the various time points of epidemic, linear regression model was used by adjustment for age, sex, BMI, and baseline SBP during the preepidemic phase. The coefficient of variation of morning BP within patients in Wuhan and other provinces was compared using the Student *t* test.

The proportions of patients according to categories of the number of drugs and drug classes were compared by χ^2 test. The number of antihypertensive drugs were compared over the 5 time periods of epidemic between 2 groups by generalized linear model adjusted for age, sex, and BMI.

Since patients in the STEP trial were randomized into an intensive BP control or a standard BP control group, a sensitivity analysis stratified by the 2 treatment groups was further conducted to examine the fluctuation in morning BP during the pandemic. A 2-tailed *P* of ≤0.05 was considered to be significant. Analyses were performed using Statistical Package for the Social Sciences (SPSS) (version 20.0; IBM Corp, Armonk, NY).

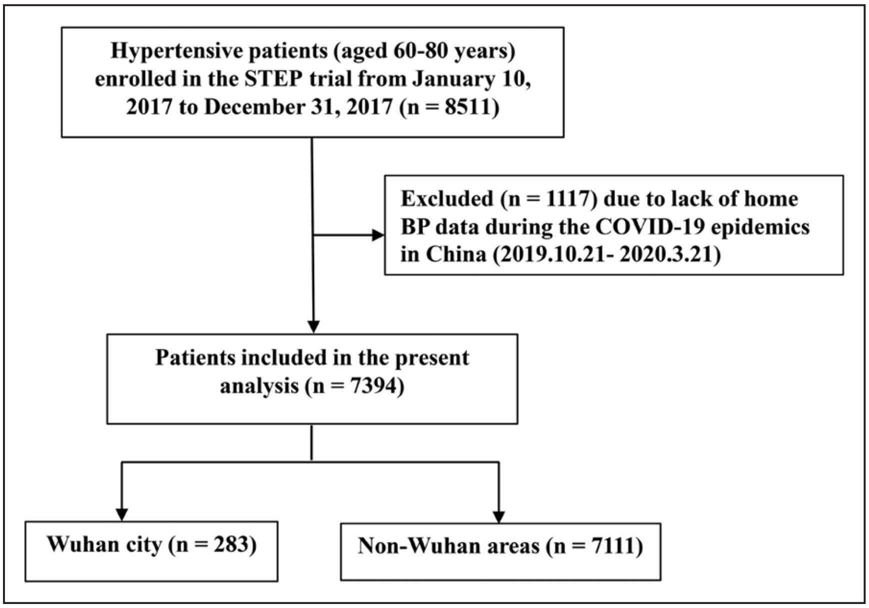

Figure 1. Flowchart of the current research. BP indicates blood pressure; COVID-19, coronavirus disease 2019; and STEP, Strategy of Blood Pressure Intervention in the Elderly Hypertensive Patients.

RESULTS

Clinical Characteristics of Studied Patients

This study included 7394 patients with hypertension aged 60 to 80 years (283 in Wuhan and 7111 in other provinces of China). The mean age was 68.6 (SD 4.8) years, of whom aged ≥70 years accounted for 30.8%, men accounted for 46.4%, and 19.1% had prior diabetes, 6.0% had prior coronary heart diseases, and 64.3% were at high-risk with the 10-year Framingham risk score ≥15%. There were no significant differences between patients in Wuhan and in non-Wuhan regions, except that those in Wuhan had a lower level of serum fasting glucose and triglycerides (Table 1).

Trajectory Pattern of Home BP During the COVID-19 Period

Patients in Wuhan paid more attention to self-monitoring of BP during the pandemic. The average number of home BP measurements and transmissions was around 4.1 to 4.5 days/week per patient in Wuhan during preepidemic phase (October 21 to November 20, 2019) and increased rapidly to 4.5 to 4.9 days/wk after the outbreak since January 21, 2020. In contrast, for patients in non-Wuhan regions, BP measurements remained stable during the pandemic, which was 3.9 to 4.4 days/week per patient (Figure III in the Data Supplement).

Patients in Wuhan had higher average morning SBP (adjusted for age, sex, and BMI) and higher BP variablility during the epidemic growth phases, which returned to normal at the plateau phase (Figure 2). In non-Wuhan areas, the adjusted average morning SBP fluctuated <1 mm Hg, with an average of 131 mm Hg, although reaching a statistical significance. In addition, there were no significant differences in trajectory pattern of average morning SBP of patients in each geographic division, including Northern, Northeastern, Northwestern, Eastern, Central, Southern, and Southwestern regions of China (Figure IV in the Data Supplement).

Changes in average morning SBP (ΔSBP) were significantly greater in Wuhan compared with non-Wuhan areas, and after adjusted for age, sex, BMI, and baseline SBP at the preepidemic phase, the between-group differences in ΔSBP were 2.5, 3.0, and 2.1 mm Hg at the incubation phase, developing phase and outbreak phase of the COVID-19, respectively (*P*<0.001; Table 2). Interestingly, from the preepidemic to the outbreak phase, the rate of patients with uncontrolled BP (≥140/90 mm Hg) decreased greatly from 26.5% to 18.0% in Wuhan and from 21.3% to 17.2% in non-Wuhan areas (*P*<0.001; Table III in the Data Supplement).

Regarding BP medication, the average number of antihypertensive drugs used in patients had an increased tendency along with the trend of elevated BP during the pandemic, which increased from 1.84 to 1.87 in Wuhan and from 1.80 to 1.82 in non-Wuhan areas (Figure 2), but these changes did not reach statistical significance. Regimen changes was significantly higher in patients in Wuhan accounting for 6.4%, 19.4%, 21.6%, and 22.3% at the incubation, developing, outbreak and plateau phases, compared with 3.1%, 9.9%, 14.9%, and 15.5% of patients in non-Wuhan areas, respectively (*P*<0.01). More patients in Wuhan also received an increased dose or drug addition compared with non-Wuhan patients. There was no change in the proportion of patients taking 1, 2, or 3 antihypertensive agents, and drug classes (including calcium channel blocker, angiotensin receptor blocker, beta-blocker, and diuretics) between Wuhan and non-Wuhan areas during the pandemic. Data were shown in Table IV in the Data Supplement.

Sensitivity analysis showed a similar trend in the trajectory pattern of change in average morning SBP in the treatment and control groups of the STEP trial (Tables V and VI and Figure V in the Data Supplement). Furthermore, home BP variability evaluated by the coefficient of variation of morning SBP in Wuhan was significantly higher than other regions by 0.4% to 0.7% during the 4 time periods of epidemic including the incubation, developing, outbreak, and plateau phases (Table VII in the Data Supplement).

Efficiency in BP Monitoring via the App During the Pandemic

Logs of doctors and patients accessing to BP module via the app were analyzed to assess the efficiency of smartphone-based BP monitoring during the pandemic (Figure VI in the Data Supplement). Overall, the average number of app visits per doctor fell dramatically during the pandemic, which were 30.4, 10.4, and 0.4 times per month in Wuhan and 50.3, 44.8, and 33.3 times per month in non-Wuhan areas during the 3 time phases of pandemic. In contrast, the frequency of checking BP by patients via the app continuously increased compared with the preepidemic period, and overall it was higher in Wuhan than in non-Wuhan areas (Figure VI in the Data Supplement).

DISCUSSION

In this study, we used longitudinal data of home BP monitored via a mobile app in a total of 7394 elderly patients with hypertension from an ongoing trial to evaluate the BP variability during the COVID-19 outbreak in China. A time period from Oct 2019 to March 2020 was divided into the preepidemic, incubation, developing, outbreak, and plateau phases, and our data first provided evidence that patients in Wuhan (the pandemic center) had higher average morning home SBP and higher SBP variability compared with other regions of China during the epidemic growth phase, which then returned

Table 1. Baseline Characteristics of Included Patients in Wuhan and Non-Wuhan Areas of China in the Present Study

Characteristics at the preepidemic phase	Included patients			P value*
	Total (n=7394)	Wuhan (n=283)	Non-Wuhan (n=7111)	
Age, y	68.6±4.8	68.3±4.8	68.6±4.8	0.35
Distribution of age, no. (%)				
60–70 y	5112 (69.1)	203 (71.7)	4909 (69.0)	0.57
≥70 y	2282 (30.9)	80 (28.3)	2202 (31.0)	
Men, no. (%)	3429 (46.4)	146 (51.6)	3283 (46.2)	0.07
Body mass index, kg/m^2	25.6±3.1	25.6±3.5	25.6±3.1	0.85
Morning SBP, mm Hg	131.2±9.8	132.1±10.0	131.1±9.8	0.10
<140 mm Hg, no. (%)	6026 (81.5)	220 (77.7)	5806 (81.6)	0.24
140–149 mm Hg, no. (%)	1167 (15.8)	53 (18.7)	1114 (15.7)	
>150 mm Hg, no. (%)	201 (2.7)	10 (3.1)	191 (2.7)	
Morning DBP, mm Hg	79.6±7.7	80.5±7.7	79.6±7.7	0.05
Fasting glucose, mmol/L	6.2±1.7	6.0±1.5	6.2±1.7	0.02
Lipids profile, mmol/L				
Total cholesterol	4.9±1.2	4.9±1.0	4.9±1.2	0.74
Triglycerides	1.3 (1.0–2.0)	1.2 (0.9–1.8)	1.4 (1.0–1.9)	0.002
HDL-C	1.3±0.3	1.3±0.3	1.3±0.3	0.10
LDL-C	2.7±0.9	2.7±0.8	2.7±0.9	0.31
Educational level, no. (%)				
Middle school or below	4182 (56.7%)	174 (61.5)	4008 (56.4)	0.09
High school or above	3212 (43.3%)	109 (38.5)	3103 (43.6)	
Smoking status, no. (%)				
Never	5293 (71.8)	188 (67.1)	5105 (72.0)	0.20
Former	889 (12.1)	41 (4.6)	848 (12.0)	
Current	1192 (16.2)	51 (18.2)	1141 (16.1)	
Alcohol intake, no. (%)				
Never	5060 (68.6)	180 (64.3)	4880 (68.8)	0.26
Former	377 (5.1)	15 (5.4)	362 (5.1)	
Current	1936 (26.3)	85 (30.4)	1851 (26.1)	
Medical history, no. (%)				
Diabetic	1414 (19.1)	62 (21.9)	1352 (19.0)	0.23
Coronary heart disease	441 (6.0)	11 (3.9)	430 (6.0)	0.13
The 10-y risk of CVD, %†	19.3±8.5	19.4±8.6	19.3±8.5	0.93
The 10-y risk of CVD ≥15%, no. (%)†	4758 (64.3)	186 (66.4)	4572 (64.6)	0.57

CVD indicates cardiovascular disease; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; and SBP, systolic blood pressure.

*Values were given as mean±SD, number (%), or median (interquartile range). *P* value, Wuhan vs non-Wuhan, were calculated by Student *t* test or Mann-Whitney test *U* for quantitative variables, or by χ^2 test for qualitative variables, when appropriate.

†The 10-y CVD risk was estimated by Framingham risk scoring, and patients with a ≥15% risk score were considered at high risk.

to normal at the plateau phase. Patients in Wuhan had a significantly increased regimen change in antihypertensive drugs during the outbreak compared with non-Wuhan patients. Expectedly, the doctors were less likely to monitor the app for BP control of patients during the pandemic. The strengths of this study include the use of a large cohort, a smartphone-based home BP monitoring, comparison of multiple time-periods before and during the epidemic period, and further sensitivity analysis comparing patients randomized to the intensive versus standard BP control.

The fluctuation of BP in patients with hypertension is closely related to the severity of pandemic and emergency actions taken by the Chinese government. Since cases

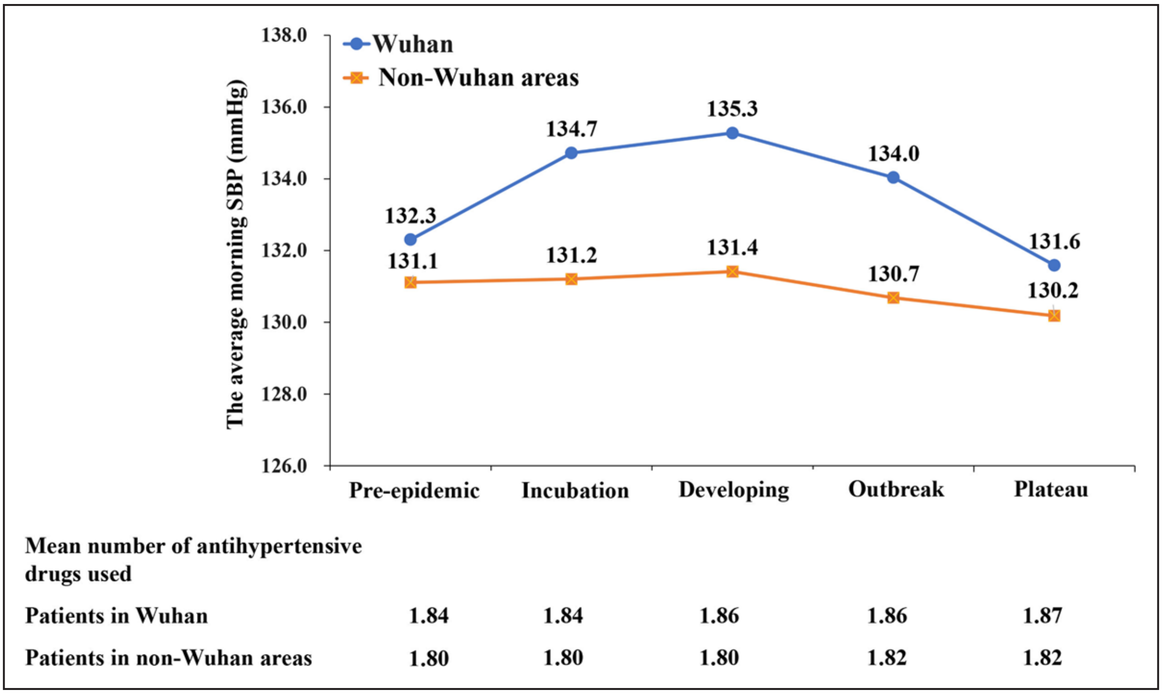

Figure 2. Trajectory pattern of morning systolic blood pressure (SBP) and antihypertensive medications in elderly patients during the pandemic.
The timeline of the coronavirus disease 2019 (COVID-19) pandemic in Wuhan was classified as the preepidemic phase as the reference (October 21 to November 20, 2019), incubation phase (November 21 to December 20, 2019), developing phase (December 21, 2019 to January 20, 2020), outbreak phase (January 21 to February 20, 2020), and plateau phase (February 21 to March 21, 2020). The values in the graphs indicated as the adjusted mean of monthly average morning SBP within each phase of the pandemic in Wuhan (blue line) and non-Wuhan areas of China (orange line), after adjustment for age, sex and body mass index.

with the COVID-19 infection were first reported in Wuhan in early December 2019, the epidemic rapidly outbroke and spread throughout China in January 2020, which greatly challenged the physical and mental health of Wuhan residents due to a serious shortage of medical resources at that time. Fortunately, in mid-January 2020, the Chinese government has activated the high-level public health emergency responses to control the spread of this pandemic, for example, rapidly screening the suspected patients, dispatching medical volunteers to support Wuhan, and building FangCang shelter hospitals. Until late February, the number of daily confirmed cases decreased dramatically and reduced to zero on March 21, 2020.[11]

Clinical studies have shown that change in SBP may be a prognostic surrogate marker for predicting cardiovascular outcomes,[13,14] and SBP controlling can greatly reduce the risk of cardiovascular events including coronary heart disease, stroke, and heart failure.[15,16] Zheng et al[17] recently reported that a short-term rise in SBP confers a stronger impact on cardiovascular outcomes compared with long-term SBP change in patients with hypertension. In this study, we provided evidence that the outbreak of COVID-19 is significantly associated with transient increase in SBP among elderly patients with hypertension, indicating the clinical importance of BP variability in patients at high risk. More evidence is needed to assess whether this short-term change in BP during the pandemic would affect long-term outcomes.

Tele-monitoring and smartphone-based BP monitoring can achieve more effective hypertension management and greater patient adherence compared with traditional method of self-monitoring home BP.[4–6,18] One important strength of this study is that the smartphone-based app platform has been used to monitor home BP for patients. Several modules are designed in the app aiming to facilitate BP control and medication adherence, for example, sending reminders to patients to check their BP and to take their medications, generating the graphical track of daily, weekly, and monthly home BP data during the follow-up period, allowing the interactive communication between patients and doctors, as well as providing patients with cardiovascular health education.

In this study, interestingly, from the preepidemic to the outbreak phase, the rate of uncontrolled BP (≥140/90 mm Hg) significantly went down in both Wuhan and non-Wuhan areas (P<0.001) although the average morning SBP increased compared with the preepidemic period. There are several possible explanations for this phenomenon. First, patients paid close attention to personal health during the outbreak and more likely to check their BP. Via the app, patients can get reminders regarding hypertension management such as taking their medications and keeping healthy dietary patterns, although they had limited outdoor exercises and experienced more anxieties about the pandemic situation. Second, during this special period, doctors were mandated to contact patients by telephone to modulate the medications if home BP readings were not within the target range according to the monthly BP report. Consistently, the antihypertensive drugs were observed to

Table 2. Change in Average Morning SBP of Patients in Wuhan and Non-Wuhan Areas of China During the COVID-19 Period

COVID-19 period	Adjusted mean (95% CI) of SBP, mm Hg*			Adjusted mean difference (95% CI) of SBP (ΔSBP), mm Hg†		Between-group difference in ΔSBP	*P* value‡
	In Wuhan (n=283)	In non-Wuhan areas (n=7111)	*P* value*	In Wuhan (n=283)	In non-Wuhan areas (n=7111)		
Preepidemic phase	132.4 (131.3 to 132.4)	131.2 (131.0 to 131.4)	0.03				
Incubation phase	134.7 (133.6 to 135.8)†	131.3 (131.1 to 131.5)	<0.001	2.6 (1.8 to 3.4)	0.1 (−0.05 to 0.2)	2.5 (1.7 to 3.3)	<0.001
Developing phase	135.1 (134.0 to 136.2)§	131.6 (131.4 to 131.7)§	<0.001	3.3 (2.5 to 4.2)	0.4 (0.2 to 0.5)	3.0 (2.1 to 3.9)	<0.001
Outbreak phase	133.9 (132.7 to 135.0)§	130.8 (130.6 to 131.1)§	<0.001	1.7 (0.7 to 2.7)	−0.4 (−0.6 to −0.2)	2.1 (1.1 to 3.1)	<0.001
Plateau phase	131.2 (130.2 to 132.3)	130.1 (129.9 to 130.3)§	0.06	−0.6 (−1.6 to 0.4)	−0.9 (−1.1 to −0.7)	0.3 (−0.7 to 1.3)	0.52

The timeline of COVID-19 outbreak was classified as the preepidemic phase as the reference (October 21 to November 20, 2019), incubation phase (November 21 to December 20, 2019), developing phase (December 21, 2019 to January 20, 2020), outbreak phase (January 21 to February 20, 2020), and plateau phase (February 21 to March 21, 2020). BMI indicates body mass index; COVID-19, coronavirus disease 2019; and SBP, systolic blood pressure.

*Adjusted mean (95% CI) of SBP was calculated by linear mixed model after adjustment for age, sex, and body mass index (BMI), and *P* Value was compared between patients in Wuhan and in non-Wuhan areas of China.

†Adjusted mean difference (95% CI) of SBP (ΔSBP) was calculated as the change of average morning SBP from preepidemic phase to each time period of COVID-19.

‡*P* Value was compared between patients in Wuhan and in non-Wuhan areas of China by linear regression model after adjustment for age, sex, BMI, and baseline SBP during the preepidemic phase.

§*P*<0.001, each phase of epidemic vs the preepidemic phase (as the reference group), calculated by linear mixed model adjusting for age, sex, and BMI.

increase along with the pandemic, and more patients in Wuhan had an increased regimen change in antihypertensive drugs than non-Wuhan patients. Finally, although patients in Wuhan had higher morning SBP compared with other regions of China under the potential shock of the pandemic, the average SBP levels were overall controlled below 140 mm Hg during 5 phases of the pandemic. These data indicated that smartphone-based home BP self-monitoring is helpful to assist BP control, particularly among the elderly who suffer from unstable BP or with high risk.

However, it should be noted that since doctors were engaged in combating the pandemic, they were less likely to monitor the app for BP control of patients, and this might result in less effective management. At this moment, patients more relied on self-monitoring of BP, and the role of physicians' interaction with patients via the app became weaken. One drawback of the app is lack of the referral module for patients; thus, doctors can only communicate with their signed patients and monitor their BP, while remote monitoring cannot be taken over by other doctors in nonepidemic areas. In the future, the app can be improved by constructing a team-based care system that includes doctors and other practice providers (such as nurses, pharmacists, or physician's assistants) to strengthen the efficiency of remote monitoring and BP management, particularly in the setting of a health crisis.

For all participants in this study, doctors investigated their health status by telephone, and no patients reported that they had closely contacted with epidemic cases or diagnosed as COVID-19 infection and hospitalized. There might be several reasons. First, according to strategies of epidemic control, all residents need to report their body temperature and health status everyday. Second, patients paid more attentions to self-protection such as washing hands often, wearing masks, and going outside less. Further study is necessary to assess BP change among patients with COVID-19 infection and without.

Several major limitations in this study should also be mentioned. First, this is a clinical trial cohort and the patient population is different from nonclinical trial cohorts. The effects in other populations could be different especially as these patients are under active treatment. Second, there is a limitation given the lack of cardiovascular outcomes, and therefore it is difficult to assess how this transient change in BP affects long-term outcomes in elderly patients with hypertension. Third, the findings appeared limited to Wuhan, which was the epicenter for the pandemic outbreak and under severe stress. Changes in BP control across other parts of China were reassuringly stable.

In summary, our findings showed that the outbreak of COVID-19 caused a short-term increase of morning SBP among the elderly patients with hypertension in Wuhan. Leveraging the smartphone-based app platform as part of this clinical trial demonstrated patterns of BP control in elderly patients with hypertension in China during the COVID-19 pandemic.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Materials

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