ORIGINAL ARTICLE

Changes in Blood Pressure Outcomes Among Hypertensive Individuals During the COVID-19 Pandemic: A Time Series Analysis in Three US Healthcare Organizations

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BACKGROUND: The COVID-19 pandemic may have negatively affected medical care for and self-management of chronic hypertension. We sought to examine the impact of the pandemic on blood pressure (BP) among individuals with hypertension.

METHODS: Using an interrupted time series analysis, we compared the level and trend (slope) of BP outcomes before the public health emergency declaration (prepandemic period: August 2018 through January 2020) versus after the stay-at-home orders (pandemic period: April 2020 through November 2020) among adults with hypertension followed at 3 large health systems (n=137 593). Outcomes include systolic and diastolic BP recorded in electronic health records and the proportion of individuals with BP <140/90 mm Hg.

RESULTS: The number of BP measurements substantially dropped early in the pandemic and then gradually increased. During the pandemic period, systolic and diastolic BP increased by 1.79 mm Hg (95% CI, 1.57–2.01; P<0.001) and 1.30 mm Hg (95% CI, 1.18–1.42; P<0.001), respectively, compared with the prepandemic period. Similarly, the proportion of patients with controlled BP decreased by 3.43 percentage points (95% CI, −3.97 to −2.90; P<0.001). A trend showing increasing control in the prepandemic period (+3.19 percentage points per year [95% CI, +2.96 to +3.42]; P<0.001) flattened during the pandemic period (+0.27 percentage points per year [95% CI, −0.81 to −1.37]; P=0.62).

CONCLUSIONS: The first 8 months of the pandemic were associated with worsening BP outcomes among individuals with hypertension. Opportunities to ensure ongoing access to health care with telemedicine and home BP monitoring may mitigate adverse impacts on BP control for future disasters/emergencies. **(*Hypertension*. 2022;79:2733–2742. DOI: 10.1161/HYPERTENSIONAHA.122.19861.)** • Supplemental Material

Key Words: blood pressure ■ COVID 19 ■ electronic health records ■ hypertension ■ interrupted time series analysis ■ pandemics

Hypertension is one of the most prevalent chronic conditions, affecting over 1 billion individuals worldwide.[1] It is also the leading modifiable risk factor for cardiovascular disease, as well as a major cause of premature mortality.[2] Nevertheless, blood pressure (BP) control remains quite poor, with only 1 in 5 hypertensive adults consistently meeting recommended BP goals.[3] A recent serial cross-sectional analysis of data from the US National Health and Nutrition Examination Survey found a trend of worsening BP among adults with hypertension over the past 2 decades.[4]

There are concerns that hypertension control may have further worsened during the COVID-19 pandemic.[5,6] Lockdown mandates to contain the spread of the virus imposed strict limitations on people's movements, forced many individuals to work remotely, and resulted in the closure of schools, restaurants, shops, and gyms. These measures led

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ORIGINAL ARTICLE

NOVELTY AND RELEVANCE

What Is New?

Using clinical data from electronic health records of 3 large health care systems representing diverse populations across the United States, we found that the first 8 months of the COVID-19 pandemic were associated with worsening blood pressure control among individuals with hypertension.

What Is Relevant?

The pandemic may have negatively affected the management of chronic hypertension given decreased physical activity, disrupted sleep, unhealthy diets, increased psychosocial stress, and limited access to health care.

Clinical/Pathophysiological Implications?

Opportunities to ensure ongoing access to health care with telemedicine and home blood pressure monitoring may mitigate adverse impacts on blood pressure control for future disasters/emergencies.

Nonstandard Abbreviations and Acronyms

BP	blood pressure
COVID-19	coronavirus disease 2019
EHR	electronic health records

to decreased physical activity, disrupted sleep, unhealthy diets, greater alcohol consumption, and increased psychosocial stress, all of which are known to negatively impact BP.[7,8] Many health care practices closed during the pandemic with variable ability to transition to telemedicine visits, thereby limiting patient access to routine health care.[9] Furthermore, patient fears of COVID-19 exposure often deterred them from seeking medical care even when it was available.[10] The economic impact of the pandemic may have made it more difficult for patients to afford their hypertension medications, leading to decreased adherence.[5]

Despite these trends, high-quality data on how the COVID-19 pandemic has affected population-level hypertension control remains limited. To address this gap, we used a quasi-experimental, interrupted time series study design to examine BP outcomes among individuals with hypertension followed at 3 large, geographically distributed US health care organizations during the COVID-19 pandemic.

METHODS

Setting and Data

In order to minimize the possibility of unintentionally sharing information that can be used to re-identify private information, a subset of the data generated for this study is available from the corresponding author upon reasonable request. We extracted data from the electronic health records (EHR) of 3 large health systems: Cedars-Sinai (Los Angeles, CA), Columbia University Irving Medical Center (New York, NY), and Ochsner Health (New Orleans, LA) from August 2018 through November 2020. Cedars-Sinai and Ochsner used Epic EHR (Epic Systems) throughout the study periods while Columbia transitioned from Allscripts EHR (Allscripts Healthcare Solutions, Inc) to Epic EHR in February 2020. Extracted data included patient demographics (eg, age, sex, race, and ethnicity) and encounter information (eg, visit dates, diagnoses, and BP values).

We defined the following study periods: (1) prepandemic period (August 2018 through January 2020; 18 months), (2) transition period (February through March 2020; 2 months), and (3) pandemic period (April through November 2020; 8 months). These periods were based on 2 key events related to the COVID-19 pandemic in the United States. First, the US federal government declared a public health emergency on January 31, 2020, and determined that it had existed since January 27, 2020.[11] Second, the stay-at-home orders became effective on March 19, 22, and 23, 2020 in California, New York, and Louisiana, respectively.[12]

Study Participants

Eligibility criteria included age ≥18 years at the time of the prepandemic period and at least one primary care visit with a diagnosis of hypertension during the first 6 months of the prepandemic period (August 2018 through January 2019). Primary care visits were defined as visits to internal medicine or family medicine clinicians. Hypertension was defined using an *International Classification of Diseases, Tenth Revision, Clinical Modification* code of I10 (essential hypertension). To ensure that participants continued receiving care at study sites, we further restricted the sample to those who had at least one primary care visit for any reason during the past 12 months of the prepandemic period (February 2019 through January 2020). We excluded participants with missing data on study variables.

Outcome Variables

We examined (1) mean systolic and diastolic BPs recorded in the EHR and (2) prevalence of controlled BP defined as systolic BP <140 mm Hg and diastolic BP <90 mm Hg, as recommended by the Eighth Joint National Committee.[13] We extracted BP data in the vital signs section (clinicians were allowed to document self-reported home BP in the vital signs section for telemedicine visits). We evaluated these outcomes during each week of the study; if a participant had more than one documented BP reading during a given week, we used the lowest value. We excluded BP readings measured during acute events (eg, hospitalizations and emergency department visits) as these values are unlikely to reflect long-term BP control. We chose the threshold of <140/90 mm Hg for controlled hypertension because this is still widely used.[14]

Covariates

We included the following participant characteristics as covariates: age (as a continuous variable), sex (male or female), self-reported race (White, Black, Asian, other, or unknown), ethnicity (Hispanic or non-Hispanic), zip-code level median household income (quintiles), alcohol use (yes, no, or unknown), smoking status (current, former, or never smoker), and Charlson comorbidity index[15] (0, 1–2, 3–4, or ≥5). The zip-code level median household income was obtained from the American Community Survey.[16]

Statistical Analysis

We first described participant characteristics and the number of BP measurements per week during the study period. We then used an interrupted time series design to test whether the levels and slopes of BP outcomes changed during the pandemic period compared with the prepandemic period. We fit multivariable linear regression models for each BP outcome that included a continuous time variable (week), a dummy indicator for the pandemic period (versus prepandemic period), and an interaction term between the time variable and the pandemic period indicator, as well as the covariates. We also included health system fixed effect (ie, dummy variables for each study site) and month fixed effect to account for time-invariant health system factors and seasonality,[17] respectively. The coefficients for the pandemic period indicator and the interaction term represent the level change and slope change, respectively, during the pandemic period compared with the prepandemic period. We used linear regression models for a binary outcome (ie, BP control), instead of logistic regression models, to allow a better interpretation of the coefficients of the interaction term (ie, linear probability model).[18] SEs were clustered at the participant level to account for the autocorrelation among repeated BP measurements.

We conducted all analyses with Stata software version 17.0 (StataCorp, TX). This study was approved by the institutional review boards of each institution involved.

Stratified and Sensitivity Analyses

We conducted a series of stratified and sensitivity analyses. First, we performed stratified analysis by health system because pandemic-related public health measures varied by region, and each health system may have responded to the pandemic differently. Second, we examined whether the changes in BP outcomes differed by age group (age <65 versus ≥65 years) because evidence suggests that pandemic-related public health measures disproportionately impacted older adults economically.[19] To do so, we first fit multivariable linear regression models to evaluate the changes in BP outcomes separately for those aged <65 and ≥65 years. We then estimated *P* values for the interaction terms between each of the interrupted time series variables (ie, a continuous time variable, a pandemic period indicator, and an interaction term between the time variable and pandemic period indicator) and age group indicator using the total sample to formally test whether the changes in BP outcomes differed between the 2 age groups. Third, we conducted a stratified analysis by sex (male versus female) using the same approach given similar evidence of a larger impact on females compared with males.[20] Fourth, we conducted a sensitivity analysis by restricting our sample to participants with at least one BP measurement during the transition and pandemic periods. These participants were thought to represent either those with uncontrolled BPs (ie, needing more medical attention) or those who were able to continue to receive care at study sites (eg, did not lose health insurance). Fifth, we reanalyzed the data by subdividing the pandemic period into early (April 2020) and late (May through November 2020) periods because there were fewer BP measurements during the early period. Last, we evaluated BP control using an alternative threshold of <130/80 mm Hg, instead of <140/90 mm Hg, based on the 2017 American College of Cardiology/American Heart Association guideline.[21]

RESULTS

Participant Characteristics

A total of 137 593 participants (Cedars-Sinai: 13 194; Columbia: 6662; and Ochsner: 117 737) were included in the study. The mean (SD) age was 66.2 (13.3) years, 57.2% were female, 62.1% were White, 30.1% were Black, and 4.8% were Hispanic (Table 1). The mean (SD) number of BP measurements per participant during the study period was 11.2 (8.4). During the prepandemic period, 77.8% of participants had controlled BP (ie, systolic <140 and diastolic <90). Participant characteristics differ by study site including race and ethnicity, zip-code level median household income, and prepandemic BP control (Table 1).

Changes in Number of BP Measurements Over Time

In the pooled data, the number of BP measurements began to decline during the transition period, dropped substantially early in the pandemic, then gradually increased later in the pandemic. By the end of the study, the pooled number of BP measurements remained below the level of the prepandemic period (Figure 1) for 2 reasons: (1) 15.6% of the participants did not have BP measurements during the transition or pandemic period and (2) participants had BP measurements less frequently during the transition and pandemic periods (every 2.6 months on average) compared with the prepandemic period (every 2.2 months). These findings were similar across the 3 study sites.

Changed in Mean Pooled BP Over Time

After adjusting for participant characteristics and seasonality, we found that mean pooled systolic and diastolic BP increased by 1.79 mm Hg (95% CI,

Table 1. Characteristics of Study Participants by Study Site

Characteristics	Total (n=137 593)	Cedars-Sinai (n=13 194)	Columbia (n=6662)	Ochsner (n=117 737)
Age, mean (SD)	66.2 (13.3)	69.5 (13.5)	69.9 (12.1)	65.6 (13.3)
Female	78 742 (57.2%)	7182 (54.4%)	4634 (69.6%)	66 926 (56.8%)
Race				
White	85 419 (62.1%)	7915 (60.0%)	821 (12.3%)	76 683 (65.1%)
Black	41 482 (30.1%)	2601 (19.7%)	787 (11.8%)	38 094 (32.4%)
Asian	2617 (1.9%)	1598 (12.1%)	154 (2.3%)	865 (0.7%)
Other	2547 (1.9%)	720 (5.5%)	295 (4.4%)	1532 (1.3%)
Unknown	5528 (4.0%)	360 (2.7%)	4605 (69.1%)	563 (0.5%)
Hispanic	6560 (4.8%)	1343 (10.2%)	2663 (40.0%)	2554 (2.2%)
Zip-code level median household income				
Lowest quintile	28 481 (20.7%)	450 (3.4%)	1605 (24.1%)	26 426 (22.4%)
Second quintile	28 302 (20.6%)	2160 (16.4%)	1135 (17.0%)	25 007 (21.2%)
Third quintile	26 535 (19.3%)	1202 (9.1%)	2776 (41.7%)	22 557 (19.2%)
Fourth quintile	29 911 (21.7%)	1161 (8.8%)	903 (13.6%)	27 847 (23.7%)
Highest quintile	24 364 (17.7%)	8221 (62.3%)	243 (3.6%)	15 900 (13.5%)
Alcohol				
Yes	59 099 (43.0%)	6149 (46.6%)	607 (9.1%)	52 343 (44.5%)
No	70 610 (51.3%)	6656 (50.4%)	3191 (47.9%)	60 763 (51.6%)
Unknown	7884 (5.7%)	389 (2.9%)	2864 (43.0%)	4631 (3.9%)
Smoking status				
Current smoker	15 131 (11.0%)	630 (4.8%)	417 (6.3%)	14 084 (12.0%)
Former smoker	43 248 (31.4%)	4524 (34.3%)	1922 (28.9%)	36 802 (31.3%)
Never smoker	79 214 (57.6%)	8040 (60.9%)	4323 (64.9%)	66 851 (56.8%)
Charlson comorbidity index				
0	36 322 (26.4%)	3227 (24.5%)	1581 (23.7%)	31 514 (26.8%)
1–2	43 527 (31.6%)	4221 (32.0%)	2670 (40.1%)	36 636 (31.1%)
3–4	27 810 (20.2%)	2582 (19.6%)	1372 (20.6%)	23 856 (20.3%)
≥5	29 934 (21.8%)	3164 (24.0%)	1039 (15.6%)	25 731 (21.9%)
No. of BP measurements during the study period, mean (SD)	11.2 (8.4)	11.7 (8.9)	10.3 (5.7)	11.2 (8.4)
Prepandemic BP control				
SBP<140 and DBP<90	107 062 (77.8%)	10 222 (77.5%)	4348 (65.3%)	92 492 (78.6%)
SBP 140–159 and DBP 90–99	26 269 (19.1%)	2747 (20.8%)	2051 (30.8%)	21 471 (18.2%)
SBP≥160 or DBP≥100	4262 (3.1%)	225 (1.7%)	263 (3.9%)	3774 (3.2%)

We included those age ≥18 y who had 2 primary care visits with a diagnosis of hypertension during the prepandemic period (August 2018 through January 2020; see the main text for more details). DBP indicates diastolic blood pressure; and SBP, systolic blood pressure.

1.57–2.01; P<0.001) and 1.30 mm Hg (95% CI, 1.18–1.42; P<0.001), respectively, during the pandemic period relative to the prepandemic period (Table 2 and Figure 2). While the slope for systolic BP during the pandemic period (−0.65 mm Hg per year [95% CI, −1.09 to −0.22]; P=0.003) did not change significantly from baseline (−0.78 mm Hg per year [95% CI, −0.87 to −0.68]; P<0.001), the slope for diastolic BP significantly decreased from the baseline slope of −0.72 mm Hg per year (95% CI, −0.77 to −0.66; P<0.001) to −1.25 mm Hg per year (95% CI, −1.49 to −1.01; P<0.001).

Changes in Achievement of Controlled BP Over Time

The proportion of participants with controlled BP decreased by 3.43 percentage points (95% CI, −3.97 to −2.90, P<0.001) during the pandemic period compared with the prepandemic period. A trend toward increasing control that had been observed in the prepandemic period (+3.19 percentage points per year [95% CI, +2.96 to +3.42]; P<0.001) flattened during the pandemic period (0.27 percentage points per year [95% CI, −0.81 to −1.37]; P=0.62).

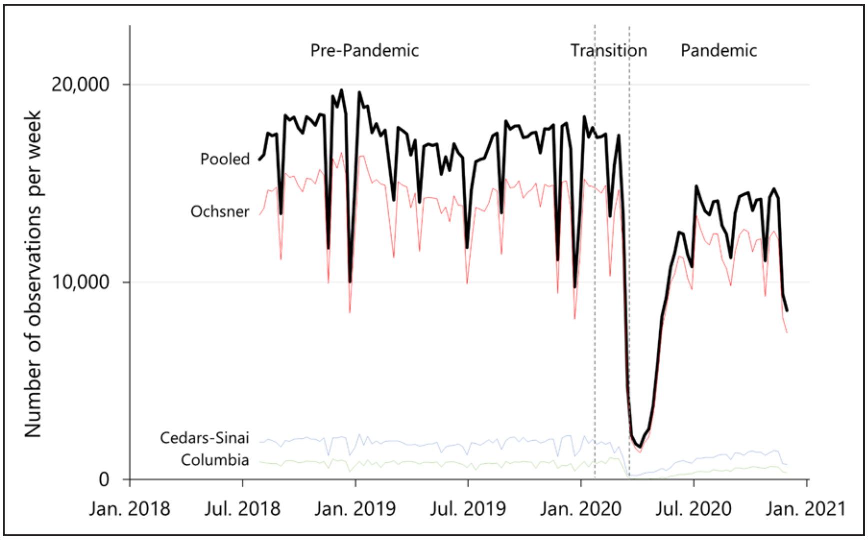

Figure 1. Changes in the number of blood pressure measurements per week by study site.
The study period was from August 2018 through November 2020 (prepandemic period: August 2018 through January 2020; pandemic period: April 2020 through November 2020). The unit of analysis is a blood pressure measurement.

Stratified and Sensitivity Analyses

Our stratified analysis by health system showed similar changes in BP outcomes during the study period, although the 3 health systems had significantly different prepandemic BP levels (Table 2 and Figure 2). The stratified analysis by age group showed that, compared with participants aged <65 years, those aged ≥65 had a larger increase in diastolic BP (*P*-for-interaction <0.001) and a smaller decrease in BP control (*P*-for-interaction=0.04), while the differences were relatively small (Table 3). The stratified analysis by sex showed no evidence that the changes in systolic and diastolic BP, as well as BP control, differ between males and females (Table 3).

In the 3 sensitivity analyses restricting the sample to those who had at least one BP measurement during the transition and pandemic periods (n=116 147; Table S1), separating the pandemic period into early and late periods (Table S2), and using the BP control threshold of 130/80 mm Hg (Table S3) yielded similar findings to the main analysis.

DISCUSSION

In this study of pooled BP data from 3 large US health care organizations in areas severely affected by the COVID-19 pandemic, we found that the frequency of documented BP readings sharply declined in the early stages of the pandemic, then gradually rebounded later

Table 2. Estimates of Changes in Level and Slope of Blood Pressure Outcomes During the Pandemic

Outcome	Level		Slope (per year)	
	Adjusted change[95% CI]	*P* value	Adjusted change [95% CI]	*P* value
Systolic blood pressure, mm Hg				
Pooled	+1.79 [+1.57 to +2.01]	<0.001	+0.12 [−0.33 to +0.58]	0.59
Cedars-Sinai	+1.15 [+0.45 to +1.84]	0.001	−0.06 [−1.51 to +1.39]	0.94
Columbia	+0.97 [−0.57 to +2.52]	0.22	+1.42 [−1.52 to +4.35]	0.34
Ochsner	+1.90 [+1.67 to +2.13]	<0.001	+0.09 [−0.39 to +0.58]	0.70
Diastolic blood pressure, mm Hg				
Pooled	+1.30 [+1.18 to +1.42]	<0.001	−0.54 [−0.78 to −0.29]	<0.001
Cedars-Sinai	+1.63 [+1.21 to +2.05]	<0.001	−0.73 [−1.58 to +0.13]	0.09
Columbia	+0.76 [−0.01 to +1.54]	0.05	+0.80 [−0.71 to +2.30]	0.30
Ochsner	+1.32 [+1.20 to +1.45]	<0.001	−0.63 [−0.90 to −0.37]	<0.001
Blood pressure <140/90, %				
Pooled	−3.43 [−3.97 to −2.90]	<0.001	−2.91 [−4.04 to −1.79]	<0.001
Cedars-Sinai	−1.33 [−3.11 to +0.46]	0.15	−3.77 [−7.45 to −0.09]	0.04
Columbia	−5.64 [−9.40 to −1.89]	0.003	−0.80 [−8.05 to +6.44]	0.83
Ochsner	−3.71 [−4.28 to −3.14]	<0.001	−2.72 [−3.92 to −1.52]	<0.001

For each outcome, we fit multivariable linear regression models including a continuous time variable (week), a dummy indicator for the pandemic period, and an interaction term between the time variable and the pandemic period indicator, as well as the covariates. SEs were clustered at the participant level. Slopes per year were calculated by multiplying 52 to slopes per week.

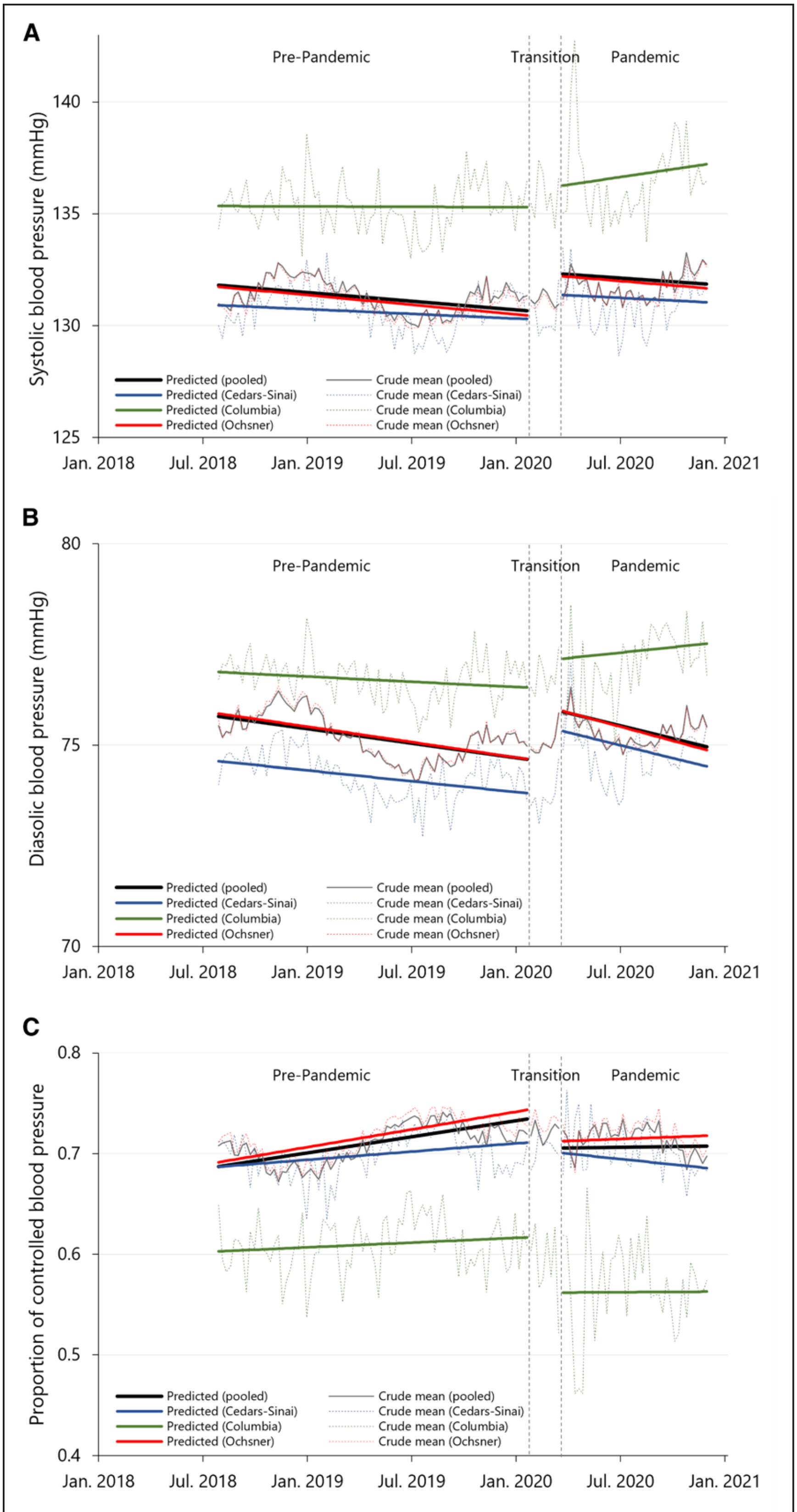

Figure 2. Changes in the blood pressure outcomes during the study period.
Data shown are crude (unadjusted) means and predicted values from multivariable linear regression models for (**A**) systolic blood pressure, (**B**) diastolic blood pressure, and (**C**) proportion of controlled blood pressure (<140/90 mm Hg). See the main text for more details.

in the pandemic but did not return to the prepandemic baseline. We also observed a small but significant increase in both systolic and diastolic BPs as well as a decrease in BP control during the pandemic. Although BP control appeared to be improving in the prepandemic period, this trend plateaued once the pandemic

Table 3. Estimates of Changes in Level and Trend of Blood Pressure Outcomes During the Pandemic Stratified by Age Group (<65 and ≥65) and Sex (Male and Female)

Outcome	Level			Slope (change per year)		
	Adjusted change [95% CI]	*P* value	*P*-for-interaction	Adjusted change [95% CI]	*P* value	*P*-for-interaction
Age						
Systolic blood pressure, mm Hg						
Age <65	+2.06 [+1.71 to +2.40]	<0.001	0.06	−0.64 [−1.35 to +0.06]	0.07	0.006
Age ≥65	+1.63 [+1.35 to +1.91]	<0.001		+0.58 [+0.00 to +1.17]	0.049	
Diastolic blood pressure, mm Hg						
Age <65	+1.03 [+0.83 to +1.23]	<0.001	<0.001	−0.37 [−0.78 to +0.04]	0.08	0.12
Age ≥65	+1.45 [+1.31 to +1.60]	<0.001		−0.64 [−0.95 to −0.33]	<0.001	
Blood pressure <140/90, %						
Age <65	−4.22 [−5.10 to −3.34]	<0.001	0.04	−1.72 [−3.55 to +0.11]	0.07	0.28
Age ≥65	−3.00 [−3.68 to −2.33]	<0.001		−3.59 [−5.01 to −2.17]	<0.001	
Sex						
Systolic blood pressure, mm Hg						
Male	+1.99 [+1.65 to +2.33]	<0.001	0.96	+0.39 [−0.31 to +1.08]	0.28	0.006
Female	+1.66 [+1.38 to +1.94]	<0.001		−0.06 [−0.65 to +0.53]	0.84	
Diastolic blood pressure, mm Hg						
Male	+1.29 [+1.10 to +1.48]	<0.001	0.25	−0.31 [−0.71 to +0.08]	0.11	0.02
Female	+1.31 [+1.16 to +1.46]	<0.001		−0.70 [−1.01 to −0.38]	<0.001	
Blood pressure <140/90, %						
Male	−3.91 [−4.75 to −3.08]	<0.001	0.90	−2.81 [−4.56 to −1.07]	0.002	0.15
Female	−3.10 [−3.80 to −2.41]	<0.001		−3.01 [−4.47 to −1.55]	<0.001	

See the main text for the details of these stratified analyses by age group and sex. Slopes per year were calculated by multiplying 52 to slopes per week.

began. Similar changes in BP outcomes were observed across the 3 health care systems despite differences in site-specific participant sociodemographics and baseline BP control.

Potential mechanisms of the persistent decrease in BP monitoring during the pandemic include cancelation or postponement of follow-up face-to-face visits to avoid exposure to COVID-19, limited access to telemedicine, and loss of insurance from unemployment. Although the rebound in BP measurements suggests rapid response by health systems (eg, telemedicine), early evidence shows that patients of racial or ethnic minorities, limited English proficiency, or low digital literacy are less likely to access to telemedicine.[22] Along with factors derived from pandemic-related public health measures (eg, decreased physical activity, psychosocial stress), disruptions in BP monitoring also likely contributed to the worsening BP outcomes we observed as multiple prior studies have shown that BP monitoring is associated with better hypertension control.[23,24] Additionally, initial reports suggesting that the use of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers may lead to increased COVID-19 severity may have further fueled nonadherence to these antihypertensive medications, although this association was later disproved.[25]

Our study extends the findings of previous research examining the changes in BP control during the COVID-19 pandemic. Data from a US employer-sponsored wellness program showed an increase in office-measured BP (by 1.1–2.5 mm Hg in systolic and 0.1–0.5 mm Hg in diastolic BP) during the pandemic versus prepandemic.[26] Another study using home BP data from participants self-enrolled in a US digital health hypertension control program found that, compared with prepandemic participants, participants during the pandemic had higher systolic (by 1.9 mm Hg) and diastolic BPs (by 1.2 mm Hg).[27] Recent descriptive data from 24 US health systems also showed that the proportion of uncontrolled BP averaged across health systems dropped from 60.5% in 2019 to 53.3% during the pandemic.[28] Conversely, studies conducted in France,[29] Italy,[30,31] and Brazil[32] have found either no change or improvement in BP during the pandemic. While informative, these studies may suffer from several limitations. Many did not collect detailed clinical information about their study participants and were therefore unable to control for important potential confounders, such as medical comorbidities.[26–29,32,33] Some compared different patient populations during the prepandemic and pandemic periods, making them subject to selection bias.[27,28] Studies conducted in other countries may not be generalizable to US patient populations (eg, the degree of disruption in health care system and shortage of medical resources might have differed by country).[29,30,32–34] We provide new evidence on how the pandemic affected BP control among hypertensive individuals using longitudinal clinical data from EHR of 3 large health care systems representing diverse populations across the United States.

The mean pooled adjusted increase in systolic (1.79 mm Hg) and diastolic BP (1.30 mm Hg) during the pandemic period relative to the prepandemic period that we found was of a similar magnitude to pandemic-related BP changes reported by prior population-based studies in the United States.[26,27] Although these findings may appear modest for an individual patient, they have important implications for population health outcomes given that an increase in population-level BP of as little as 2 mm Hg has been associated with significantly elevated rates of heart attack, stroke, heart failure, and mortality.[35–37] For example, one estimate suggests that a 2 mm Hg increase in systolic BP can elevate the risk of major cardiovascular disease events by 5%.[36] In addition, the disruption in BP control might have been worse without swift response to the pandemic by health systems, such as a transition to telehealth. Future longitudinal studies are needed to better understand what factors drove these worsening BP outcomes, how the BP changes observed during the pandemic may translate into adverse cardiovascular outcomes, and whether BP levels return to prepandemic levels in the long run.

It is important to note that 15.6% of the study participants did not have BP measurements during the transition or pandemic period. There are several potential reasons. Patients with worse hypertension or greater comorbidities may have been more likely to seek care during the pandemic than those with milder hypertension or fewer comorbidities (possibly biasing our estimates away from the null). However, those who lost health insurance or had limited access to telemedicine may have been less likely to be represented during the pandemic period (possibly biasing our estimates toward the null). We attempted to account for this by conducting a sensitivity analysis that restricted the sample to those who had at least one BP measurement during the transition or pandemic periods, which yielded similar results to the main analysis.

Our stratified analyses showed little or no difference in the changes in BP outcomes during the pandemic period between younger versus older adults and males versus females, despite early evidence of a disproportionate impact of pandemic-related public health measures, particularly economic consequences, on older adults and females.[19,20] There are several possible explanations for these findings. First, while older adults may have had more limited access to health care by avoiding exposure to COVID-19 and by having difficulties with telehealth (eg, inexperience with technology, hearing impairment[38]), younger adults might have experienced a more negative impact on their mental health and well-being than older adults.[39] Second, our study participants, who had visited their primary care providers regularly before the pandemic, may have economic stability in general and are affected by the pandemic to a lesser extent than the broader population, leading to minimal differences across subgroups.

Limitations

Our study has several limitations. First, the study sample included only those patients who were already engaged in the health care system prior to the pandemic and thus may not have been fully representative of the source population. Second, our data did not include BP values recorded as free text, which might have been obtained via home self-monitoring, an increasingly common practice in recent years and especially accelerated in the context of the pandemic. Third, the way in which sociodemographic information (eg, race and ethnicity) was collected and recorded differed by study site and was often missing at some sites, although the fact that our findings were consistent across sites serves to strengthen our conclusions. Fourth, no information on the body mass index, physical exercise, diet, hypertension treatment, or medication adherence was available, and we were unable to incorporate the information in our analysis. Last, because we only followed patients through the first 8 months of the pandemic, we do not know if the observed BP trends will be sustained or how they might affect long-term cardiovascular outcomes.

Perspectives

This pooled cohort study of patients followed at 3 large US health care systems found a substantial decrease in the monitoring of BP coinciding with an increase in both systolic and diastolic BP, as well as a decrease in the proportion of BP control during the COVID-19 pandemic period. A previous trend of gradually improving BP control appears to have been slowed by the onset of the pandemic. These findings persisted even after accounting for differences in patient sociodemographic and clinical characteristics and were similar across all 3 study sites. While future studies are warranted, increased access to health care including preparedness for telemedicine along with home BP monitoring has the potential to mitigate future disruptions in care with other large-scale emergencies.

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Disclosures

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