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Original Article

The impact of the COVID-19 Pandemic on hypertension phenotypes (ESH ABPM COVID-19 study)

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ABSTRACT

Objective: The COVID-19 pandemic had a major impact on medical care. This study evaluated the influence of the pandemic on blood pressure (BP) control and hypertension phenotypes as assessed by office and 24-hour ambulatory BP monitoring (ABPM).

Design and Methods: Data were collected from 33 centers including Excellence Centers of the European Society of Hypertension. Two groups of patients with treated hypertension were compared. Pandemic group: including participants who had ABPM twice - at visit 2 during the COVID-19 pandemic and visit 1 performed 9–15 months prior to visit 2. Pre-pandemic group: had ABPM at two visits, performed before the pandemic within 9–15 months interval. We determined the following hypertension phenotypes: masked hypertension, white coat hypertension, sustained controlled hypertension (SCH) and sustained uncontrolled hypertension (SUCH). We analyzed the prevalence of phenotypes and their changes between visits.

Results: Data of 1419 patients, 616 (43 %) in the pandemic group and 803 (57 %) in the pre-pandemic group, were analyzed. At baseline (visit 1), the prevalence of hypertension phenotypes did not differ between groups. In the pandemic group, the change in hypertension phenotypes between two visits was not significant ($p = 0.08$). In contrast, in the pre-pandemic group, the prevalence of SCH increased during follow-up (28.8 % vs 38.4 %, $p < 0.01$) while the prevalence of SUCH decreased (34.2 % vs 27.8 %, $p < 0.01$). In multivariable adjusted analysis, the only factor influencing negative changes of hypertension phenotypes was the COVID-19 pandemic period.

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Conclusion: These results indicate a negative impact of the COVID-19 pandemic on BP control assessed by hypertension phenotypes.

1. Introduction

The COVID-19 pandemic had a significant impact on various aspects of public health. The imposed restrictions forced people to spend more time at home, which may have resulted in a decline in physical activity and a deterioration of diet quality in affected populations including patients with hypertension [1,2]. Due to limited access to medical care, some patients did not attend regular medical follow-up visits [3], which led to delays in diagnosing diseases related to unhealthy lifestyles [4]. Moreover, difficulties in monitoring patients with already diagnosed cardiovascular diseases (CVD), including hypertension, was often associated with the inability to modify their treatment.

Numerous studies have already shown a relationship between the COVID-19 pandemic and worsening of blood pressure (BP) control [5,6], but there are also reports that prove otherwise [7,8]. Despite the outcome, most analyses concentrate on the one method of measuring BP at home or in office. An important supplementary method to these measurements is 24 h ambulatory blood pressure monitoring (ABPM). ABPM provides a higher number of BP data and enables assessment of BP control over a 24 h period. The use of two methods may substantially increase accuracy of BP control assessment. By combining the ABPM result with the office measurement, four main hypertension phenotypes can be specified: sustained controlled hypertension (SCH), white-coat hypertension (WCH), masked hypertension (MH) and sustained uncontrolled hypertension (SUCH). The evaluation of these phenotypes is of interest because they have been associated with differences in CV risks [9–11].

In a previous report of the European Society of Hypertension (ESH) ABPM COVID-19 Study a negative impact of the COVID-19 pandemic on BP control in absolute BP values based on ABPM was observed [12]. The current study is based on the analysis of the same data, yet offering a different perspective on the issue of BP control. The aim of this study is to extend previous findings by evaluating the impact of the COVID-19 pandemic on changes in hypertension phenotypes.

2. Methods

Clinical and BP data were collected from 33 centers including Excellence Centers of the European Society of Hypertension. A full description of the study protocol was published in a previous report of the ESH ABPM COVID-19 Study [13]. The study was conducted according to the principles outlined in the Helsinki declaration for investigations in human subjects, and general data protection regulations. The study protocol received the approval of the local Ethics Committee in the countries of participating centers.

Table 1
Description of categories of hypertension phenotypes change from visit 1 to visit 2.

Deterioration-worsening	WCH → SUCH
	SCH → SUCH
	MH → SUCH
	SCH → MH
	SCH → WCH
Improvement or no-change	SUCH → SCH
	SUCH → WCH
	SUCH → MH
	WCH → SCH
	MH → SCH
	SCH → SCH
	MH → MH
	WCH → WCH
Uncontrolled with no definite improvement or worsening	WCH → MH
	MH → WCH
	SUCH → SUCH

SCH – sustained controlled hypertension; SUCH – sustained uncontrolled hypertension; WCH – white coat hypertension; MH – masked hypertension.

2.1. Study material

Two groups of patients with treated hypertension were compared. Group 1 (pandemic): including participants who had ABPM twice - at visit 2 during the COVID-19 pandemic and at visit 1 performed 9–15 months prior to visit 2. Group 2 (pre-pandemic): had ABPM at two visits, performed before the pandemic within 9–15 months interval.

The onset of the pandemic was defined by the formal declaration of the World Health Organization on March 11th in 2020. Consequently, the following periods of time were set as inclusion criteria. In Group 1, visit-2 was eligible from 01.04.2020 to 31.03.2021 and visit 1 before 31.12.2019 (9–15 months prior to visit 2).

In Group 2, visit 2 was eligible from 01.01.2019 to 31.12.2019 and visit 1 about 9–15 months before visit 2.

2.2. Hypertension phenotypes and clinical data collection

The average of 24-hour systolic BP (SBP) and diastolic BP (DBP) as well as office SBP and DBP were collected. Only ABPM recordings fulfilling previously defined quality criteria, i.e. at least 20 valid awake and 7 valid asleep measurements were eligible for the study [14].

The following hypertension phenotypes in treated subjects were distinguished and listed in line with their increasing negative prognostic significance:

1) sustained controlled hypertension (office SBP <140 mm Hg and DBP <90 mm Hg, and 24-hour SBP <130 mm Hg and DBP <80 mm Hg),
2) white coat hypertension (office SBP ≥140 mm Hg and/or DBP ≥90 mm Hg, and 24-hour SBP <130 mm Hg and DBP <80 mm Hg),
3) masked hypertension (office SBP <140 mm Hg and DBP <90 mm Hg, and 24-hour SBP ≥130 mm Hg and/or DBP ≥80 mm Hg),
4) sustained uncontrolled hypertension (office SBP ≥140 mm Hg and/or DBP ≥90 mm Hg, and 24-hour SBP ≥130 mm Hg and/or DBP ≥80 mm Hg).

Hypertension phenotypes were determined at both visit 1 and visit 2. The patients were classified based on changes in their phenotype between two visits into three categories (Table 1 provides a detailed description of the categories):

1. Deterioration-worsening (DW)
2. Improvement or no-change (INC)
3. Uncontrolled with no definite improvement or worsening (UN)

Clinical data were gathered and entered to the data form when available. Data regarding the antihypertensive drug class, dosing change or drug discontinuation were also collected. Differences in use of antihypertensive drugs between visit 1 and visit 2 (drug classes, change in dose, and initiation or discontinuation) were classified into three categories: unchanged, increase or decrease.

2.3. Statistical methods

Database management and statistical analysis were performed using SPSS statistical software (IBM Statistics 29; Chicago, IL, USA).

Table 2
Clinical characteristics of the study participants at baseline visit according to distinguished categories of hypertension phenotypes change between visits.

	All patients (n = 1419)	Deterioration-worsening (n = 298)	Improvement or no-change (n = 828)	Uncontrolled with no definite improvement or worsening (n = 293)	P_{ANOVA}
Age, [years]	59.2 ± 14.7	59.3 ± 14.9	59.3 ± 14.5	58.6 ± 15.1	0.78
Male sex	713 (50.2 %)	140 (47 %)	426 (51.4 %)	147 (50.2 %)	0.42
BMI [kg/m^2]	28.7 ± 4.9	28.7 ± 4.5	28.5 ± 4.9	29.2 ± 5.3	0.22
Participants from pandemic group	616 (43.4 %)	149 (50 %)*	329 (39.7 %)	138 (47.1 %)	**0.003**
Current smoking	197 (15.5 %)	38 (12.8 %)	119 (14.4 %)	40 (13.7 %)	0.70
Duration of hypertension [years]	10 (4 – 17)	10 (5 – 17)	9 (4 – 16)	10 (4 – 18)	0.39
Alcohol intake	223 (21 %))	46 (15.4 %)	123 (14.9 %)	54 (18.4 %)	0.92
Office SBP	130.1 ± 20.6	130.2 ± 14.7*	136.6 ± 19#	155.2 ± 21.3&	**< 0.001**
Office DBP	83.3 ± 13.3	79.5 ± 10.8*	81.9 ± 12.3#	91.1 ± 15.1&	**< 0.001**
24 h SBP	129.1 ± 15.6	122.2 ± 11.7*	126.9 ± 14.3#	142.3 ± 15.1&	**< 0.001**
24 h DBP	75.9 ± 10.9	72.1 ± 8.3*	75.1 ± 10.2#	82.1 ± 12.8&	**< 0.001**
Comorbidities:					
• **Diabetes mellitus**	355 (24.9 %)	74 (24.8 %)	195 (23.6 %)	86 (29.4 %)	0.14
• **CKD**	216 (15.2 %)	46 (15.4 %)	112 (13.5 %)#	58 (19.8 %)	**0.04**
• **AF**	131 (9.2 %)	29 (9.7 %)	78 (9.4 %)	24 (8.2 %)	0.78
• **CAD**	158 (11.1 %)	35 (13.7 %)	83 (10 %)	40 (13.7 %)	0.30
• **Stroke**	154 (10.9 %)	37 (12.4 %)	87 (10.5 %)	30 (10.2 %)	0.62

Data are presented as mean ± standard deviation or number and percent or median with confidence interval. BMI – body mass index; CKD – chronic kidney disease; AF – atrial fibrillation; CAD – coronary artery disease.
* $p < 0.05$ for differences between deterioration-worsening and improvement or no-change category.
# $p < 0.05$ for differences between improvement or no-change and uncontrolled with no definite improvement or worsening category.
& $p < 0.05$ for differences between uncontrolled with no definite improvement or worsening and deterioration-worsening category.

Table 3
Antihypertensive drug classes taken at baseline according to distinguished categories of hypertension phenotypes change between visits.

	Deterioration-worsening (n = 298)	Improvement or no-change (n = 828)	Uncontrolled with no definite improvement or worsening (n = 293)	p
ACEI	88 (29.53 %)	262 (31.68 %)	97 (33.11 %)	0.64
ARB	154 (51.68 %)	386 (46.62 %)	140 (47.78 %)	0.33
CCB	190 (63.76 %)	513 (61.96 %)	205 (69.97 %)	0.05
BB	155 (52.01 %)	417 (50.36 %)	154 (52.56 %)	0.77
Thiazide	114 (38.26 %)	313 (37.80 %)	125 (42.66 %)	0.33
Loop	48 (16.11 %)	100 (12.08 %)#	54 (18.43 %)	**0.027**
K+ sparing diuretics	45 (15.10 %)	156 (18.84 %)	63 (21.50 %)	0.13
Other	42 (14.09 %)	108 (13.04 %)#	72 (24.57 %)&	**< 0.001**

ACEI – angiotensin converting enzyme inhibitors; ARB – angiotensin receptor blocker; BB – beta blockers; CCB – calcium channel blockers; Thiazide – thiazide and thiazide-like diuretic; Loop – loop diuretic; Other – other antihypertensive treatment (alpha-blockers, central agents).
# $p < 0.05$ for differences between improvement or no-change and uncontrolled with no definite improvement or worsening category.
& $p < 0.05$ for differences between uncontrolled with no definite improvement or worsening and deterioration-worsening category.

Continuous variables are presented as means and standard deviations. Categorical variables are expressed as percentages. Differences between groups were assessed using one-way analysis of variance (ANOVA). Post hoc analyses were performed using Fisher's Least Significant Difference test for continuous variables. Categorical variables were compared by the Pearson's χ^2 test and for those all post hoc analyses were performed using the Bonferroni adjustments. Logistic regression analysis was used to investigate independent factors of phenotypes deterioration. P values <0.05 were considered statistically significant.

3. Results

Out of the 1620 patients included in the study, we excluded those with missing ABPM or clinical data precluding to define hypertension phenotypes. Consequently, 1419 patients (616 (43 %) from pandemic and 803 (57 %) from pre-pandemic group) met the criteria for analysis in the present study. Among them 298 (21 %) were categorized as deterioration-worsening of hypertension phenotype, 828 (58 %) as improvement or no-change, 293 (21 %) patients were uncontrolled with no definite improvement or worsening.

The baseline characteristics and between hypertension phenotypes categories comparisons are presented in Table 2. Patients in the distinguished categories did not differ with regard to gender, age, BMI index, current smoking status and alcohol intake or history of hypertension. At the baseline visit, distinguished categories differed in office SBP and DBP values and average 24-hour SBP and DBP values, with the highest values in UN category. In UN category there was a significantly higher rate of chronic kidney disease than in INC (19.8 % vs 13.5 %, $p < 0.04$). The prevalence of other comorbidities such as diabetes mellitus, atrial fibrillation, coronary artery disease and stroke as well as laboratory results did not differ between analyzed categories. In addition, only in the UN category the change in BMI index between visits was statistically significant (28.7 ± 4.5 vs. 29.3 ± 5, $p = 0.03$).

In our analysis, the only factor differentiating deterioration-worsening category from improvement or no-change category was the number and percentage of patients from pandemic group (50 % vs 39.7

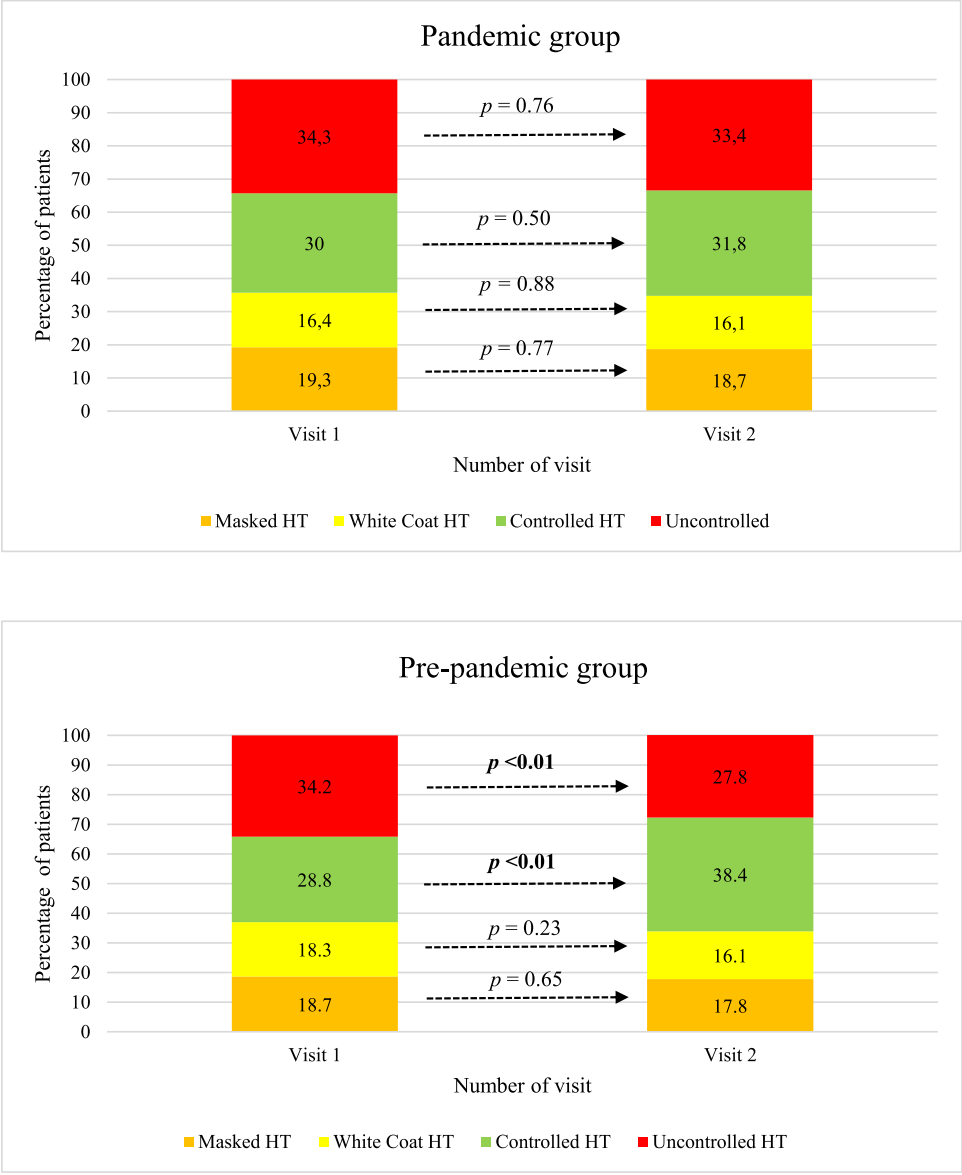

Fig. 1. Prevalence of hypertension phenotypes in pandemic and pre-pandemic group between visits.

%, $p < 0.003$).

Table 3 summarizes the antihypertensive drugs used in each category at visit 1. The use of loop diuretics was more prevalent in the UN than in the INC category. The usage of other drugs was lower in DW and INC categories than in UN. The Supplementary Table 1 summarizes the frequency of each drug class at the second visit.

In the DW category, the dosage of beta-blockers decreased as compared to other categories. In the INC category, maintenance of dosage was more common within beta-blockers and loop diuretics in comparison to other categories. In the UN category, the dosage of calcium channel blockers increased in comparison to other categories.

The prevalence of hypertension phenotypes within the pandemic and pre-pandemic groups are presented in Fig. 1. At baseline visit, the prevalence of hypertension phenotypes did not differ between groups ($p = 0.80$). In the pandemic group, there was also no change in the frequency of hypertension phenotypes at visit 2 compared with visit 1 ($p = 0.08$). In contrast, in the pre-pandemic group, the prevalence of SCH increased at the second visit (28.8 % vs 38.4 %, $p < 0.01$) while the prevalence of SUCH decreased (34.2 % vs 27.8 %, $p < 0.01$). Fig. 2 shows the transition between phenotypes. In the pre-pandemic group, a greater number of patients with SCH maintained their phenotype than in the pandemic group (64.5 % vs 51.3 %, $p < 0.01$). Additionally, in the pre-pandemic group, a greater proportion of patients with MH improved to SCH than in the pandemic group (35.3 % vs 25.2 %), while a smaller proportion of patients with MH deteriorated to SUCH (19.3 % vs 29.4 %), however these differences did not reach statistical significance.

In multivariable adjusted analysis of between categories differences (Supplementary Table 1), any change in treatment was not a factor related to deterioration of hypertension phenotype. The only significant factor influencing the negative changes of hypertension phenotypes was the COVID-19 pandemic period.

4. Discussion

Numerous studies have assessed the impact of the COVID-19 pandemic on BP control, but the results of these studies are inconsistent. There are data that showed a lack of influence [8] or even improvement in BP control during pandemic [15]. Increasing number of studies however prove otherwise [5,6,16]. This study extends the methodology used in previously published data [12,13] with a more

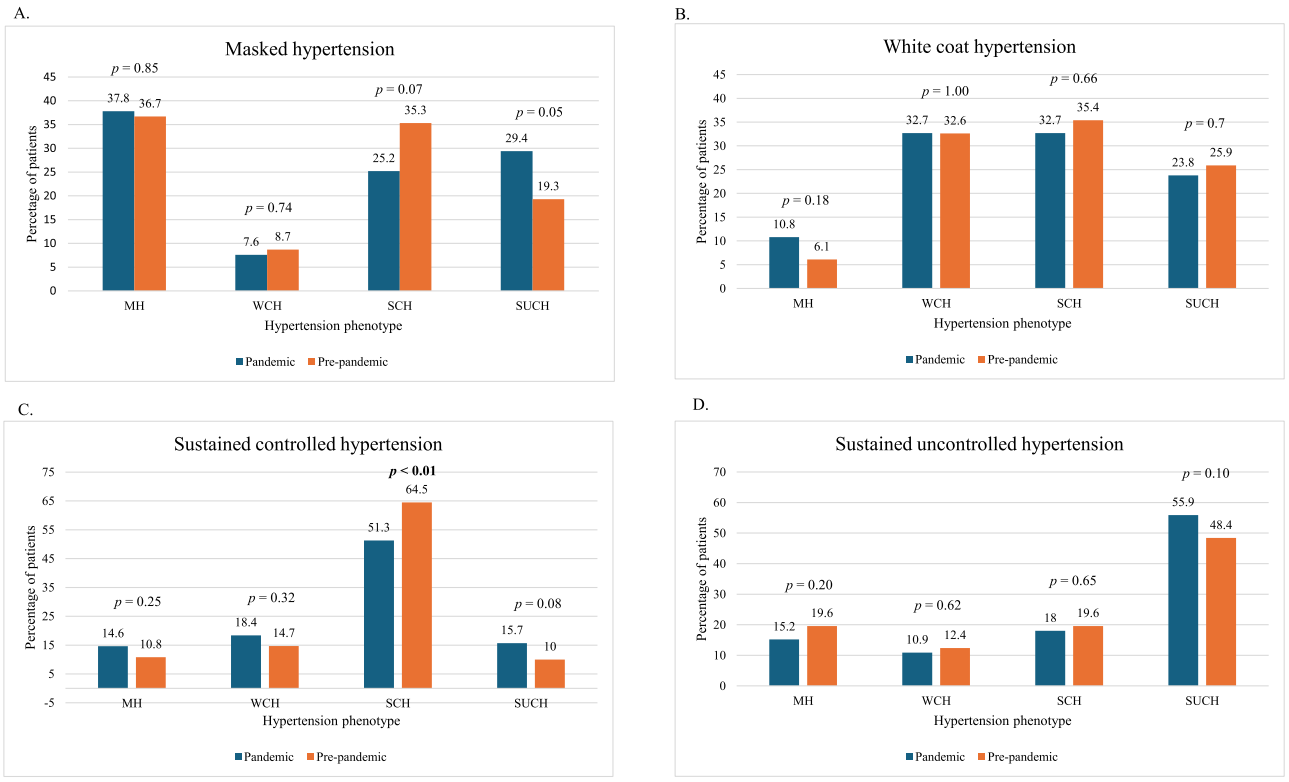

Fig. 2. Panel A. Hypertension phenotypes at visit 2 in pandemic and pre-pandemic group in patients with masked hypertension on visit 1.
Panel B. Hypertension phenotypes at visit 2 in pandemic and pre-pandemic group in patients with white coat hypertension on visit 1.
Panel C. Hypertension phenotypes at visit 2 in pandemic and pre-pandemic group in patients with sustained controlled hypertension on visit 1.
Panel D. Hypertension phenotypes at visit 2 in pandemic and pre-pandemic group in patients with sustained uncontrolled hypertension on visit 1.
MH – masked hypertension; WCH – white coat hypertension; SCH – sustained controlled hypertension; SUCH – sustained uncontrolled hypertension; BP – blood pressure.

Table 4
Antihypertensive drug classes taken at follow-up according to distinguished categories of hypertension phenotypes change between visits.

	Deterioration-worsening (n = 298)	Improvement or no-change (n = 828)	Uncontrolled with no definite improvement or worsening (n = 293)	p
ACEI	90 (30.20 %)	246 (29.71 %)	92 (31.40 %)	0.86
ARB	151 (50.67 %)	405 (48.91 %)	143 (48.81 %)	0.86
CCB	184 (61.74 %)	508 (61.35 %)[#]	220 (75.09 %)[&]	**< 0.001**
BB	143 (47.99 %)	425 (51.33 %)	161 (54.95 %)	0.24
Thiazide	112 (37.58 %)	337 (40.70 %)	130 (44.37 %)	0.24
Loop	43 (14.43 %)	106 (12.80 %)[#]	59 (20.14 %)	**0.01**
K+ sparing diuretics	52 (17.45 %)	171 (20.65 %)	76 (25.94 %)[&]	**0.049**
Other	46 (15.44 %)	110 (13.29 %)[#]	81 (27.65 %)[&]	**< 0.001**

ACEI – angiotensin converting enzyme inhibitors; ARB – angiotensin receptor blocker; BB – beta blockers; CCB – calcium channel blockers; Thiazide – thiazide and thiazide-like diuretic; Loop – loop diuretic; Other – other antihypertensive treatment (alpha-blockers, central agents).
*$p < 0.05$ for differences between deterioration-worsening and improvement or no-change category.
[#] $p < 0.05$ for differences between improvement or no-change and uncontrolled with no definite improvement or worsening category.
[&] $p < 0.05$ for differences between uncontrolled with no definite improvement or worsening and deterioration-worsening category.

accurate hypertension phenotyping, which is an important complement of common office and home BP measurements interpretation. By using office BP and 24-hour ABPM, we determined the baseline hypertension phenotypes as recommended by ESH 2023 Guidelines [17] and assessed, whether they change from pre-pandemic to pandemic visits. In our study, we confirmed the result of previous study, that the COVID-19 pandemic had not only a negative impact on BP control but also on hypertension phenotype deterioration [12]. This study showed that the expected improvement in hypertension phenotypes was observed in the pre-pandemic period due to appropriate hypertension treatment and patients' control. The main finding during the pandemic was the lack of a positive change in phenotypes despite treatment. These results suggest that medical care in the pre-pandemic period worked more effectively, patients were better monitored and changes in hypertension treatment were implemented more effectively.

Unfortunately, we do not know the exact medical reasons for changes in antihypertensive treatment in studied categories. The most likely explanation for drug changes is medical indication, such as bradycardia for beta-blockers, peripheral oedema for calcium channel blockers, introduction of loop diuretics for uncontrolled hypertension and renal diseases. However, this remains speculative.

Despite the outcome, that any change in treatment was not a factor related to deterioration of hypertension phenotype, it can be observed, that the highest prevalence of treatment changes was within the UN hypertension category. Possible explanation is that patients from the UN category require more medical supervision and more frequent visits.

Table 5
Changes in antihypertensive drug classes between visits according to distinguished categories of hypertension phenotypes change.

	Deterioration-worsening ($n = 298$)	Improvement or no-change ($n = 828$)	Uncontrolled with no definite improvement or worsening ($n = 293$)	p
ACEI				0.20
decreased	14 (4.70 %)	54 (6.52 %)	19 (6.48 %)	
increased	29 (9.73 %)	59 (7.13 %)	32 (10.92 %)	
unchanged	255 (85.57 %)	715 (86.35 %)	242 (82.59 %)	
ARB				0.37
decreased	18 (6.04 %)	48 (5.80 %)	23 (7.85 %)	
increased	29 (9.73 %)	92 (11.11 %)	40 (13.65 %)	
unchanged	251 (84.23 %)	688 (83.09 %)	230 (78.50 %)	
CCB				**< 0.001**[#,&]
decreased	35 (11.74 %)	93 (11.23 %)	22 (7.51 %)	
increased	37 (12.42 %)	123 (14.86 %)	75 (25.60 %)	
unchanged	226 (75.84 %)	612 (73.91 %)	196 (66.89 %)	
BB				**0.005**[*,#,&]
decreased	37 (12.42 %)	62 (7.49 %)	25 (8.53 %)	
increased	31 (10.40 %)	75 (9.06 %)	48 (16.38 %)	
unchanged	230 (77.18 %)	691 (83.45 %)	220 (75.09 %)	
Thiazide				0.32
decreased	32 (10.74 %)	59 (7.13 %)	27 (9.22 %)	
increased	33 (11.07 %)	102 (12.32 %)	39 (13.31 %)	
unchanged	233 (78.19 %)	667 (80.56 %)	227 (77.47 %)	
Loop				**< 0.001**[*,#]
decreased	18 (6.04 %)	18 (2.17 %)	13 (4.44 %)	
increased	12 (4.03 %)	29 (3.50 %)	25 (8.53 %)	
unchanged	268 (89.93 %)	781 (94.32 %)	255 (87.03 %)	
K+ sparing diuretics				**0.04**[#]
decreased	11 (3.69 %)	37 (4.47 %)	15 (5.12 %)	
increased	18 (6.04 %)	53 (6.40 %)	34 (11.60 %)	
unchanged	269 (90.27 %)	738 (89.13 %)	244 (83.28 %)	
Other				**< 0.001**[*,#,&]
decreased	10 (3.36 %)	27 (3.26 %)	21 (7.17 %)	
increased	25 (8.39 %)	35 (4.23 %)	56 (19.11 %)	
unchanged	263 (88.26 %)	766 (92.51 %)	216 (73.72 %)	
Any change in treatment	176 (59,06 %)	496 (59,9 %)[#]	222 (75,77 %)[&]	**<0.001**

ACEI – angiotensin converting enzyme inhibitors; ARB – angiotensin receptor blocker; BB – beta blockers; CCB – calcium channel blockers; Thiazide – thiazide and thiazide-like diuretic; Loop – loop diuretic; Other – other antihypertensive treatment (alpha-blockers, central agents); unchanged – the patient did not take the medicine on either visit or took the same dose on both; increase – increasing drug dosage or starting treatment on visit 2 over visit 1; decrease - decreasing drug dose or drug withdrawal on visit 2 over visit 1.

[*] $p < 0.05$ for differences between deterioration-worsening and improvement or no-change category.

[#] $p < 0.05$ for differences between improvement or no-change and uncontrolled with no definite improvement or worsening category.

[&] $p < 0.05$ for differences between uncontrolled with no definite improvement or worsening and deterioration-worsening category.

Sometimes, they are also patients characterized by poor compliance. Therefore, we believe that such patients may have the highest prevalence of drug treatment changes, however without of better BP control.

A growing number of research report an association between the acute phase of COVID-19 infection and the BP raise [18,19]. Nevertheless, the patients analysed in our study did not have scheduled visits during the acute phase of infection and soon after. For this reason we believe that the COVID-19 infection itself did not significantly disturb our results. Recently, attention has also been drawn to the adverse effects of SARS-CoV-2 vaccination on the increase in BP [18,20]. Although such an effect appears to be rare and temporary [21], it did not affect the results of our study, as we started the recruitment substantially before introduction of the first vaccine.

Hypertension is a major risk factor for cardiovascular mortality world-wide [22], therefore, its proper diagnosis, treatment and control are of great importance in any circumstances. By defining the hypertension phenotypes among hypertensive patients, we complement the diagnosis, which allows to better determine long term prognosis and establish treatment as well as implement appropriate monitoring [23]. All these tasks were extremely challenging during the pandemic.

Recently, the diagnosis of WCH is of increased interest because some studies have shown that WCH diagnosis increases the risk of development SUCH, almost three times compared to true normotensives individuals [24]. A negative impact of WCH on carotid atherosclerosis [25] or cardiac function [26] was also emphasized. Data also indicates that WCH is an intermediate risk category situated between those with normotension and SUCH [27]. The accurate diagnosis of MH is of even greater importance due to its association with cardiovascular risk, which has been confirmed in most studies, similar to that of SUCH [28,29].

Several previously published studies assessed the impact of the pandemic on BP control [5–8]. However, to the best of our knowledge, this is the first study analyzing its impact on the hypertension phenotypes analyzed in the current report. Our study confirmed that in the pre-pandemic period, patients treated at ESH Excellence Centers improved their hypertension phenotypes i.e. the amount of SUCH decreased, whereas SCH increased. However, similar expected improvement was not observed during the pandemic period, suggesting inadequate patient care or other interfering factors. Numerous factors could have contributed to the lack of improvement in BP control. Among them are difficulties in accessing medical facilities due to some restrictions related to lock-down as well as patients fear of getting infected in public places. Although some studies show a positive impact of the pandemic on daily habits, such as increasing physical activity or improving diet [30], our study shows, that these changes may have been insufficient in reducing or controlling BP. Adequate BP control is a matter of great importance, because poorly controlled hypertension, especially combined with additional risk factors such as increased body weight, increases the risk of mortality from SARS-CoV-2 infection [31]. The results of our study emphasize the need of appropriate medical surveillance during exceptional periods such as a global pandemic, as similar circumstances may occur at other events. Of particular importance in this regard are improved access to medical care, especially through the use of telemedicine solutions, and the wider use of self-monitoring blood pressure devices and applications. The latter, as well as long-term programs for remote monitoring and management of cardiovascular disease, will ultimately have an impact on reducing mortality from SARS-CoV-2 infection and any unprecedented circumstances in the future.

This study has some limitations including the insufficient knowledge about patients' adherence to treatment in long period between visits. We did not include patients who had a significant change in their medical history between visits. The next limitation is the representativeness of results obtained mainly from patients treated in ESH Excellence Centers for the wider spectrum of hypertensive patients. However, we assume that there may have been the same or even worse effect on hypertension phenotype during pandemic (Tables 4 and 5).

5. Conclusion

The effectiveness of treatment in the pre-pandemic period resulted in hypertension phenotypes improvement, however in the pandemic this effect was not observed. This result extends previous knowledge about the negative impact of pandemic on the effectiveness of hypertension treatment and emphasizes the need for searching better methods of hypertension long term management.

Declaration of competing interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ejim.2024.08.027.

References

[1] Zhao Z, Li L, Sang Y. The COVID-19 pandemic increased poor lifestyles and worsen mental health: a systematic review. Am J Transl Res 2023 May 15;15(5):3060–6.
[2] Kim S. Relationship between lifestyle changes due to the COVID-19 pandemic and depression: nationwide population-based research using Community health survey data in South Korea. Prim Care Diabetes 2023;17(4):359–65.
[3] Cho E, Han S, Lee JR, Lee H, Oh B. Effects of the COVID-19 pandemic on the medical use of elderly patients with hypertension: a nationwide cohort study in Korea. Korean J Fam Med 2024 Mar 4.
[4] Mularczyk-Tomczewska P, Zarnowski A, Gujski M, Jankowski M, Bojar I, et al. Barriers to accessing health services during the COVID-19 pandemic in Poland: a nationwide cross-sectional survey among 109,928 adults in Poland. Front Public Health 2022 Sep 8;10:986996.
[5] Laffin LJ, Kaufman HW, Chen Z, Niles JK, Arellano AR, et al. Rise in blood pressure observed among US adults during the COVID-19 pandemic. Circulation 2022 Jan 18;145(3):235–7.
[6] Endo K, Miki T, Itoh T, Kubo H, Ito R, et al. Impact of the COVID-19 pandemic on glycemic control and blood pressure control in patients with diabetes in Japan. Intern Med 2022;61(1):37–48.
[7] Pengo MF, Albini F, Guglielmi G, Mollica C, Soranna D, et al. Home blood pressure during COVID-19-related lockdown in patients with hypertension. Eur J Prev Cardiol 2022 Mar 25;29(3):e94–6.
[8] Feitosa FGAM, Feitosa ADM, Paiva AMG, Mota-Gomes MA, Barroso WS, et al. Impact of the COVID-19 pandemic on blood pressure control: a nationwide home blood pressure monitoring study. Hypertens Res 2022;45(2):364–8.
[9] Viera AJ, Shimbo D. Ambulatory blood pressure phenotypes and the risk for hypertension. Curr Hypertens Rep 2014;16(10):481.
[10] Wang C, Zhang J, Li Y, Ma X, Ye Z, et al. Masked hypertension, rather than white-coat hypertension, has a prognostic role in patients with non-dialysis chronic kidney disease. Int J Cardiol 2017 Mar 1;230:33–9.
[11] Fukuhara M, Arima H, Ninomiya T, Hata J, Hirakawa Y, et al. White-coat and masked hypertension are associated with carotid atherosclerosis in a general population: the Hisayama study. Stroke 2013;44(6):1512–7.
[12] Wojciechowska W, Rajzer M, Weber T, Chrostowska M, Doumas M, et al. The impact of COVID-19 pandemic on blood pressure control in patients with treated hypertension. Results of European society of hypertension study (ESH ABPM COVID-19 study). J. Hypertens. June 2023;41(Suppl 3):e32–3.
[13] Wojciechowska W, Rajzer M, Weber T, Prejbisz A, Dobrowolski P, et al. Ambulatory blood pressure monitoring in treated patients with hypertension in the COVID-19 pandemic - The study of European society of hypertension (ESH ABPM COVID-19 study). Blood Press 2023;32(1):2161998.
[14] O'Brien E, Parati G, Stergiou G, Asmar R, Beilin L, et al. European Society of Hypertension position paper on ambulatory blood pressure monitoring. J Hypertens 2013;31(9):1731–68. Erratum in: J Hypertens. 2013 Dec;31(12):2467.
[15] Girerd N, Meune C, Duarte K, Vercamer V, Lopez-Sublet M, Mourad JJ. Evidence of a blood pressure reduction during the Covid-19 pandemic and associated lockdown period: insights from e-health data. Telemed J E Health 2022;28(2):266–70.
[16] Wolf J, Nieckarz A, Panfil A, Białas A, Sternicka J, et al. Blood pressure control in tertiary-care hypertensive patients during COVID-19 pandemic. Arterial Hypertension 2023;27(3):145–51.
[17] Mancia G, Kreutz R, Brunström M, Burnier M, Grassi G, et al. 2023 ESH Guidelines for the management of arterial hypertension The Task Force for the management of arterial hypertension of the European Society of Hypertension: endorsed by the International Society of Hypertension (ISH) and the European renal association (ERA). J Hypertens 2023 Dec 1;41(12):1874–2071.
[18] Angeli F, Zappa M, Reboldi G, Gentile G, Trapasso M, et al. The spike effect of acute respiratory syndrome coronavirus 2 and coronavirus disease 2019 vaccines on blood pressure. Eur J Intern Med 2023;109:12–21.
[19] Angeli F, Zappa M, Verdecchia P. Global burden of new-onset hypertension associated with severe acute respiratory syndrome coronavirus 2 infection. Eur J Intern Med 2024;119:31–3.
[20] Simonini M, Scarale MG, Tunesi F, Manunta P, Lanzani C. Multidisciplinary epidemiological research team study group. COVID-19 vaccines effect on blood pressure. Eur J Intern Med 2022;105:109–10.
[21] Buso G, Agabiti-Rosei C, Muiesan ML. The relationship between COVID-19 vaccines and increased blood pressure: a word of caution. Eur J Intern Med 2023; 111:27–9.
[22] Kintscher U. The burden of hypertension. EuroIntervention 2013;9(Suppl R): R12–5.
[23] Galván-Oseguera H, Moreno-González A. Diagnostic and therapeutic phenotypes in patients with high blood pressure. Cardiovasc Metab Sci 2022;33(Suppl: 3): s197–210.
[24] Sivén SS, Niiranen TJ, Kantola IM, Jula AM. White-coat and masked hypertension as risk factors for progression to sustained hypertension: the Finn-Home study. J Hypertens 2016;34(1):54–60.
[25] Cuspidi C, Sala C, Tadic M, Rescaldani M, Grassi G, Mancia G. Is white-coat hypertension a risk factor for carotid atherosclerosis? A review and meta-analysis. Blood Press Monit 2015;20(2):57–63.
[26] Glen SK, Elliott HL, Curzio JL, Lees KR, Reid JL. White-coat hypertension as a cause of cardiovascular dysfunction. Lancet 1996 Sep 7;348(9028):654–7.
[27] Faria J, Mesquita Bastos J, Bertoquini S, Silva J, Polónia J. Long-term risk of progression to sustained hypertension in white-coat hypertension with normal night-time blood pressure values. Int J Hypertens 2020 Dec 22;2020:8817544.
[28] Babu M, Drawz P. Masked hypertension in CKD: increased prevalence and risk for cardiovascular and renal events. Curr Cardiol Rep 2019 May 20;21(7):58.
[29] Thakkar HV, Pope A, Anpalahan M. Masked hypertension: a systematic review. Heart Lung Circ 2020;29(1):102–11.
[30] Tessier AJ, Moyen A, Lawson C, Rappaport AI, Yousif H, et al. Lifestyle behavior changes and associated risk factors during the COVID-19 Pandemic: results from the Canadian COVIDiet online cohort study. JMIR Public Health Surveill 2023 Mar 30;9:e43786.
[31] D'Elia L, Giaquinto A, Zarrella AF, Rendina D, Iaccarino Idelson P, et al. Hypertension and mortality in SARS-COV-2 infection: a meta-analysis of observational studies after 2 years of pandemic. Eur J Intern Med 2023;108:28–36.