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ORIGINAL RESEARCH

Arterial Hypertension and Associated Risk Factors in Kazakhstan: An Analysis of Blood Pressure Screening Results from May Measurement Month 2021–2023

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ABSTRACT

***Introduction*:** May Measurement Month (MMM) is a global campaign with the aim to improve awareness of arterial hypertension (AH). Kazakhstan participated in the campaign in 2021, 2022 and 2023.

***Methods*:** During the cross-sectional 2021–2023 MMM surveys, volunteer adults (≥18 years) from cities in Kazakhstan had their blood pressure (BP) measured three times in a seated position, and received a questionnaire on their demographics, lifestyle and medical history. In those not receiving antihypertensive treatment, AH was defined as a mean systolic and/or diastolic BP ≥ 140/90 mmHg.

***Results*:** A total of 8231 individuals took part in the survey, with 1805 participants in 2021, 2410 participants in 2022 and 4016 participants in 2023. The prevalence of AH was estimated to be 37% in 2021 and 45% in 2022 and 2023. Of those identified as having AH, 51–70% were aware that they had the condition. Among those who were aware that they had AH, 68–91% were receiving antihypertensive therapy. However, 70–82% of treated participants were only receiving one to two drugs. BP was controlled to < 140/90 mmHg in 43–50% of treated participants and to < 130/80 mmHg in 15–16%.

***Conclusion*:** The 2021, 2022 and 2023 MMM campaigns showed that high proportion of AH, a low level of AH awareness and inadequate BP control in Kazakhstan. Programs are needed to increase awareness of the risks of high BP and to improve the diagnosis and effective treatment of AH.

Keywords: Disease awareness; Blood pressure; Control; Hypertension; Kazakhstan; Screening; Treatment

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Key Summary Points

Why carry out this study?

Arterial hypertension (AH) is the leading cause of cardiovascular disease burden and mortality

Data on the prevalence, awareness and treatment of AH in Kazakhstan are limited

What was learned from the study?

Up to one-third of adults who volunteered for blood pressure (BP) measurement in the 2021–2023 May Measurement Month surveys in Kazakhstan had never had their BP measured before the survey (27.2% in 2021, 18.3% in 2022 and 12.2% in 2023), and over one-third of participants were found to have AH (37% in 2021, 45% in 2022 and 45% in 2023)

Only approximately half (51%) of those with AH were aware that they had the condition in 2021, but awareness of the disorder increased over time (to 70% in 2022 and 66% in 2023)

Although 68–91% of those who were aware that they had AH were on antihypertensive medication, most were receiving only one or two drugs, and ≤ 50% of the treated hypertensive participants had their BP controlled to < 140/90 mmHg and only one in six were controlled to < 130/80 mmHg.

INTRODUCTION

Arterial hypertension (AH) is estimated to affect over 1.2 billion adults worldwide [1], and is the leading risk factor contributing to global morbidity and mortality from cardiovascular disease (CVD) and chronic kidney disease (CKD) [2]. Kazakhstan and other Central Asian countries of the former Soviet Union have some of the highest rates of CVD mortality in the world, with higher death rates occurring at younger ages than in Western European countries [3–5].

To reduce the burden of AH, it is crucial to control blood pressure (BP) using antihypertensive medication and lifestyle interventions. However, low rates of BP control among hypertensive populations reflect low rates of awareness and diagnosis of the condition, especially in low- and middle-income countries, where up to 70% of individuals with AH may be unaware of their condition and the associated risks [1, 6, 7].

Despite high CVD mortality and the importance of AH as a CVD risk factor, limited data are available on the prevalence, awareness and treatment of AH in Kazakhstan and other Central Asian countries of the former Soviet Union [5, 8, 9]. According to a small cross-sectional study conducted in the capital of Kazakhstan, Nur-Sultan, between 2012 and 2013, the overall prevalence of AH in people aged 50–75 years was 70% [9]. Among those with AH, 91% were aware of their condition, and 77% took antihypertensive medications [9]. It is, however, unlikely that these high levels of AH awareness and treatment can be generalized to the whole country.

In 2017, the International Society of Hypertension launched a project called May Measurement Month (MMM), the primary aim of which is to raise awareness of AH and the importance of BP measurement to diagnose and, therefore, manage AH. In order to estimate the prevalence of AH and increase awareness of the condition among the population, Kazakhstan joined the MMM campaign in 2021, with 8231 participants screened between 2021 and 2023.

In the study reported here, we analyzed MMM data collected in Kazakhstan between 2021 and 2023 to estimate the prevalence of AH and its risk factors, and also to assess the level of AH awareness and treatment among people with AH in Kazakhstan.

METHODS

Study Design

Data from MMM campaigns conducted in Kazakhstan in 2021, 2022 and 2023 are included

in this analysis. MMM is designed as a cross-sectional survey of BP in adults (≥ 18 years) who give informed consent to participate in the survey and have their BP measured at MMM screening sites. In the study reported here, measurement sites were set up in four cities of Kazakhstan in 2021 (Almaty, Nur-Sultan, Karaganda, Aktobe) and in one city in 2022 and 2023 (Almaty), by volunteer investigators who followed a common protocol (available on the MMM website: https://maymeasure.org/). The study was approved by the "Kazakh National Medical University named after S. Asfendiyarov" ethics committee (decision No. 8(114)) on 30 June 2021. The study was conducted in accordance with the Declaration of Helsinki of 1964 and its later amendments. Informed consent was obtained from all participants for both participation in the study and publication of the data.

Survey participants completed a simple questionnaire (Electronic Supplementary Material [ESM] Appendix 1) about demographics and medical history. The survey included a specific question asking whether participants had previously taken part in this screening project. Over the 3 years of data collection (2021–2023), no repeat participants were recorded, meaning no individuals reported prior participation. Height and weight were self-reported. Body mass index (BMI) was categorized into normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2) and obese (BMI ≥ 30.0 kg/m^2). Data were entered either directly onto the printed questionnaire or a mobile application. Surveys could also be received directly by participants through an 'MMM at home' submission site, with some participants interviewed at home by volunteer investigators (such as a neighbor or parent).

BP and heart rate were measured using valid devices (OMRON, Kyoto, Japan) by trained healthcare volunteers who followed a standard protocol [6]. Training materials were made available on the MMM website (https://maymeasure.org/). Participants had three BP and pulse rate measurements taken at 1-min intervals, after being seated for 5 min. BP was calculated from the mean of the second and third readings.

For participants who were not receiving antihypertensive therapy, AH was defined as a systolic BP (SBP) ≥ 140 mmHg and/or diastolic BP (DBP) ≥ 90 mmHg. Among those receiving antihypertensive therapy, BP < 140/90 mmHg was considered to be controlled. BP controlled to < 130/80 mmHg was also reported. Medication adherence was defined as regular use of antihypertensive medications as prescribed by healthcare providers and was based on information obtained from the respondent (self-reported).

Statistical Analysis

Data were analyzed using StatTech 2.6.1 (2020; Startech LLC, Moscow, Russia), IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA) and Epi Info™ version 7. Survey results were summarized using descriptive statistics, including absolute values and percentages for categorical data, and means ± standard deviations for continuous data.

Associations between mean SBP and DBP and variables of interest (age, BMI, self-reported medical conditions) were evaluated using linear regression. Associations between the presence of AH and risk factors (BMI, sex, age, alcohol consumption, smoking) were evaluated using logistic regression. Logistic regression was also used to assess the association between adherence to therapy and age. For all regression analyses, the odds ratio (OR, crude and/or adjusted [aOR]), 95% confidence intervals (CI) and associated p values were determined, with $p < 0.05$ indicating statistical significance. Models were adjusted for sex and age.

RESULTS

Survey Participants

Half of the screening appointments took place in healthcare settings (hospitals, clinics or pharmacies), and 42% occurred in the workplace, 4% in indoor public areas, 2% in outdoor public areas and 2% in participants' homes.

Table 1 Characteristics of the individuals participating in the survey (2021–2023)

Participant characteristics	Survey year		
	2021 (*n* = 1805 participants)	**2022 (*n* = 2410 participants)**	**2023 (*n* = 4016 participants)**
Age, years	41 ± 15	46 ± 15	46 ± 17
BMI, kg/m^2	26 ± 5	26 ± 5	26 ± 5
SBP, mmHg	123 ± 18	127 ± 19	128 ± 19
DBP, mmHg	81 ± 11	83 ± 13	82 ± 11
Heart rate, bpm	79 ± 11	80 ± 12	78 ± 10
Ethnicity			
Turkic[a]	1319 (73.1)	2003 (83.1)	3088 (76.9)
Slavic[b]	399 (22.1)	314 (13.0)	778 (19.4)
Other[c]	87 (4.8)	93 (3.9)	150 (3.7)
Last BP measurement			
Never	491 (27.2)	441 (18.3)	490 (12.2)
≤ 12 months	269 (14.9)	332 (13.8)	936 (23.3)
> 12 months	1045 (57.9)	1637 (67.9)	2587 (64.5)
Existing AH			
Yes	333 (18.4)	727 (30.2)	1200 (29.9)
No	1472 (81.6)	1683 (69.8)	2816 (70.1)
Sex			
Female	1073 (59.4)	1205 (50.0)	1942 (48.4)
Male	732 (40.6)	1205 (50.0)	2074 (51.6)
Smoking			
Yes (current)	409 (22.7)	669 (27.8)	1143 (28.5)
Previous	329 (18.2)	482 (20.0)	632 (15.7)
Never	1067 (59.1)	1259 (52.2)	2241 (55.8)
Alcohol consumption			
Never/rarely	1196 (66.3)	1981 (82.2)	3087 (76.9)
1–3 times a month	521 (28.9)	387 (16.1)	827 (20.6)
1–6 times a week	83 (4.6)	38 (1.6)	86 (2.1)
Daily	5 (0.2)	2 (0.1)	16 (0.4)

Table 1 continued

Participant characteristics	Survey year		
	2021 (*n* = 1805 participants)	**2022 (*n* = 2410 participants)**	**2023 (*n* = 4016 participants)**
Diabetes			
Yes	93 (5.2)	139 (5.8)	173 (4.3)
No	1712 (94.8)	2271 (94.2)	3843 (95.7)
Previous MI/stroke			
MI	26 (1.4)	71 (2.9)	185 (4.6)
Stroke	23 (1.3)	24 (1.0)	58 (1.4)
Both	9 (0.5)	7 (0.3)	29 (0.8)
No	1747 (96.8)	2308 (95.8)	3744 (93.2)
Daily physical exercise			
Yes	915 (50.7)	1222 (50.7)	2036 (50.7)
No	890 (49.3)	1188 (49.3)	1980 (49.3)
Education			
0 years	33 (1.8)	19 (0.8)	3 (0.2)
9 years	86 (4.8)	592 (24.6)	123 (3.0)
11–12 years	676 (37.5)	827 (34.3)	1520 (37.8)
> 12 years	1010 (56.9)	972 (40.3)	2370 (59.0)
Glucose levels			
Normal	968 (53.6)	865 (35.9)	N/A
High	106 (5.9)	175 (7.3)	N/A
Don't know	731 (40.5)	1370 (56.8)	N/A
Awareness about cholesterol			
Yes	769 (42.6)	687 (28.5)	N/A
No	1036 (57.4)	1723 (71.5)	N/A
Family history of CVD			
Yes	611 (33.9)	1047 (43.4)	N/A
No	1019 (56.5)	1036 (43.0)	N/A
Don't know	175 (9.6)	327 (13.6)	N/A
Stress level			
Low	204 (11.3)	363 (15.1)	N/A
Mean	1067 (59.1)	1664 (69.0)	N/A

Table 1 continued

Participant characteristics	Survey year		
	2021 ($n = 1805$ participants)	2022 ($n = 2410$ participants)	2023 ($n = 4016$ participants)
High	465 (25.8)	292 (12.1)	N/A
Don't know	69 (3.8)	91 (3.8)	N/A
Pregnancy			
Yes	40 (3.7)	38 (3.2)	52 (2.7)
No	1033 (96.3)	1167 (96.8)	1890 (97.3)
AH in pregnancy (including previous)			
Yes	78 (7.3)	107 (3.2)	104 (5.4)
No	995 (92.7)	1098 (96.8)	1838 (94.6)
Hormonal medications			
Hormonal contraceptives	59 (5.5)	30 (2.5)	40 (2.1)
Hormonal therapy	31 (2.9)	40 (3.3)	33 (1.7)
Both	6 (0.6)	0	0
No	977 (91.0)	1135 (94.2)	1869 (96.2)

Data are presented as the mean ± standard deviation (SD) or as a number (n) with percentage in parentheses

AH Arterial hypertension, *BMI* body mass index, *BP* blood pressure, *bpm* beats per minute, *CVD* cardiovascular disease, *DBP* diastolic blood pressure, *MI* myocardial infarction, *N/A* not available, *SBP* systolic blood pressure

[a]Kazakh, Uzbek, Tatar, Uyghur

[b]Russian, Ukrainian, Belorussian

[c]European descent, Korean, mix

As shown in Table 1, a total of 8231 individuals were included in the analyses, with 1805 individuals participating in the 2021 survey, 2401 individuals participating in the 2022 survey and 4016 individuals participating in the 2023 survey. Female patients comprised 59% of the 2021 population and 50% and 48% of the 2022 and 2023 populations, respectively. The mean age of the survey population was 41 years in 2021, and 46 years in 2022 and 2023. In all 3 years of the survey, the mean BMI was 26 kg/m^2. From 2021 to 2023, 23–29% of participants were current smokers, and approximately 2–5% reported drinking alcohol at least once per week. Approximately 5% of participants reported having diabetes, and 1–5% reported a history of myocardial infarction (MI) and/or stroke. The proportions of participants reporting that they had never had their BP measured before the survey were 27% in 2021, 18% in 2022 and 12% in 2023.

Prevalence, Awareness, Treatment and Control of AH

The overall prevalence of AH increased from 37% in 2021 to 45% in 2022 and 2023 (Table 2). Of those assessed as having AH

Table 2 Prevalence, awareness, treatment and control of arterial hypertension

Prevalence, awareness, treatment and control of AH	Survey year		
	2021 ($n = 1805$ participants)	2022 ($n = 2410$ participants)	2023 ($n = 4016$ participants)
Overall prevalence of AH	674 (37)	1086 (45)	1820 (45)
Awareness in participants with AH	333 (51)	727 (70)	1200 (66)
Treatment in participants with AH	227 (68)	592 (81)	1089 (91)
BP < 140/90 mmHg in all aware participants	183 (55)	316 (53)	530 (44)
Controlled BP in aware, treated participants			
< 140/90 mmHg	113 (50)	253 (43)	477 (44)
< 130/80 mmHg	33 (15)	94 (16)	171 (16)

Data are presented as the number (n) of individuals with the percentage in parentheses

AH Arterial hypertension, *BP* blood pressure

in the 2021 survey, only 51% were aware of their diagnosis. Awareness increased to 70% of hypertensive participants in 2022 and was maintained at a similar level in 2023 (66%).

Of those hypertensive survey participants who were aware of their condition, only 68% were on antihypertensive medications in 2021, whereas 81% and 91% were receiving antihypertensive treatment in 2022 and 2023, respectively (Table 2). In 2021, 2022 and 2023, most treated hypertensive participants (70–82%) were on a single- or two-drug therapeutic regimen, with 30–49% on monotherapy (Fig. 1).

Among those on antihypertensive therapy, BP was controlled to < 140/90 mmHg in 50%

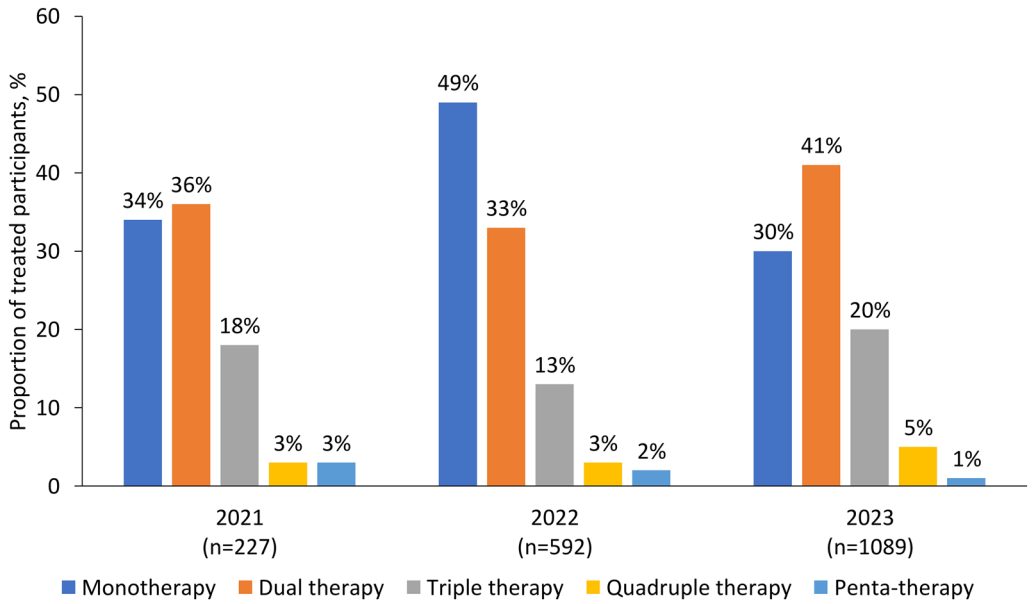

Fig. 1 Number of antihypertensive drugs in treated hypertensive survey participants in the 2021, 2022 and 2023 surveys

of participants in 2021, and in 43% and 44% of participants in 2022 and 2023, respectively (Table 2). The proportions of treated participants with BP controlled to < 130/80 mmHg were low and stable (15–16%) from 2021 to 2023. In 2021, only 46% of hypertensive participants who were aware of their condition were adherent to antihypertensive therapy, but adherence increased to 70% in 2023. Adherence to antihypertensive therapy was strongly linked to age of participants, with older people having higher adherence (aOR 1.1; 95% CI 1.0–1.1; $p < 0.001$). The same results were found for 2022 and 2023.

Risk Factors for AH

Analyses of 2021 survey results showed that mean BP increased linearly with age and BMI in participants who were not using antihypertensive therapy (Fig. 2). With an increase in age of 1 year, an increase in SBP of 0.4 mmHg and an increase in DBP of 0.2 mmHg was observed (both $p < 0.001$; Fig. 2a). SBP and DBP increased by 1.4 and 0.8 mmHg, respectively, with an increase in BMI of 1 kg/m^2 ($p < 0.001$; Fig. 2b). Mean SBP and DBP in obese or overweight participants were significantly higher than in those with normal weight ($p < 0.001$; Fig. 3). Results from the 2022 and 2023 surveys were similar in this regard.

Further analysis of the 2021 survey results showed that both SBP and DBP in participants who reported a history of both MI and stroke were significantly higher than in those with no previous stroke or MI (differences of 28 mmHg and 10 mmHg, respectively; $p < 0.05$; Fig. 4a). Participants with diabetes also had significantly higher mean SBP and DBP than those without diabetes (differences of 4 mmHg and 3 mmHg,

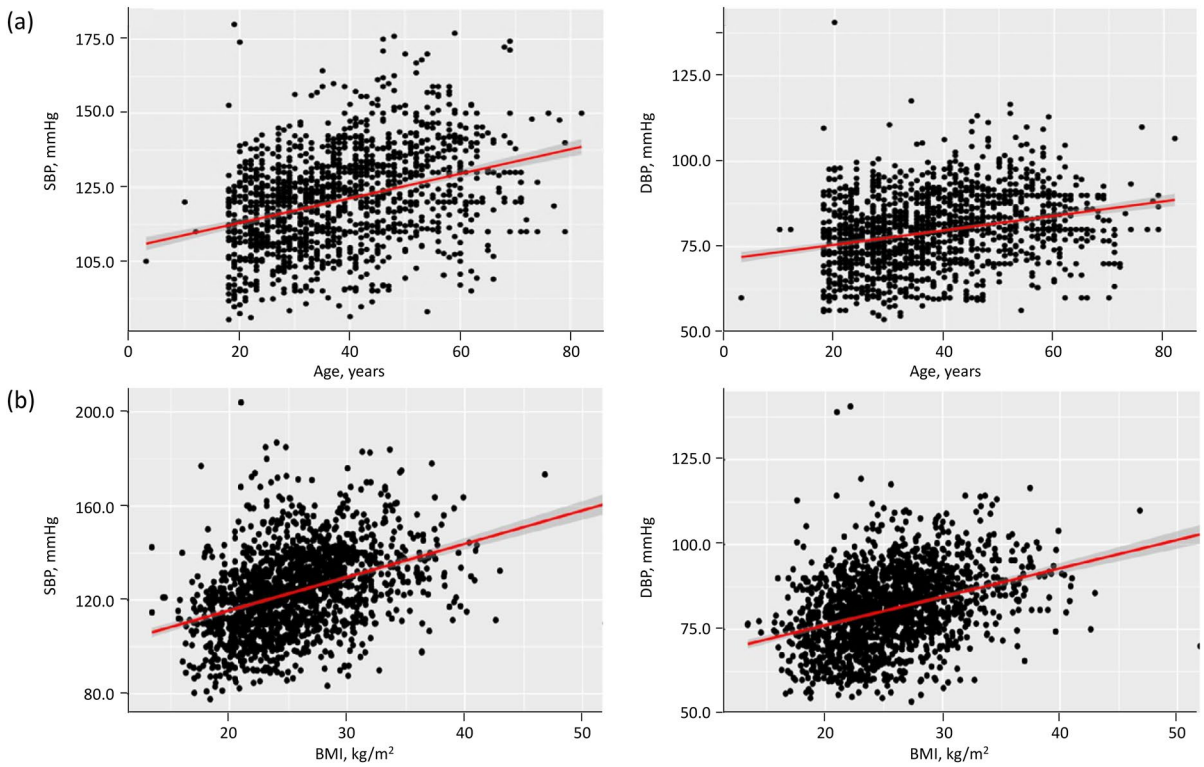

Fig. 2 Association between systolic and diastolic BP and age (**a**) and BMI (**b**) in the 2021 survey. Red line is the regression line, and the gray zone denoted the 95% confidence interval. *BMI* Body mass index, *DBP* diastolic blood pressure, *SBP* systolic blood pressure

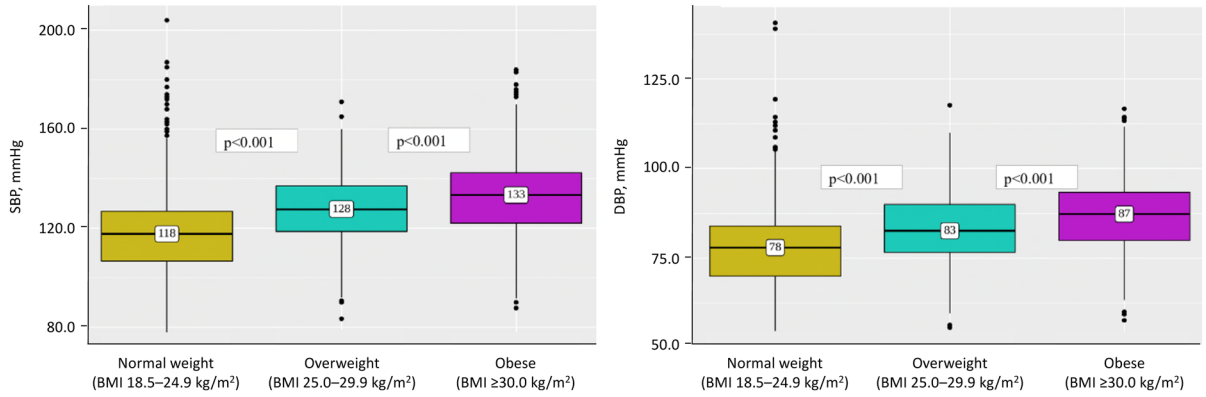

Fig. 3 Boxplot of SBP and DBP in participants with normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2) and obesity (obese; ≥ 30.0 kg/m^2) in the 2021 survey. Boxplots show the mean ± 95% confidence interval, with minimum and maximum values depicted as vertical lines. *BMI* Body mass index, *DBP* diastolic blood pressure, *SBP* systolic blood pressure

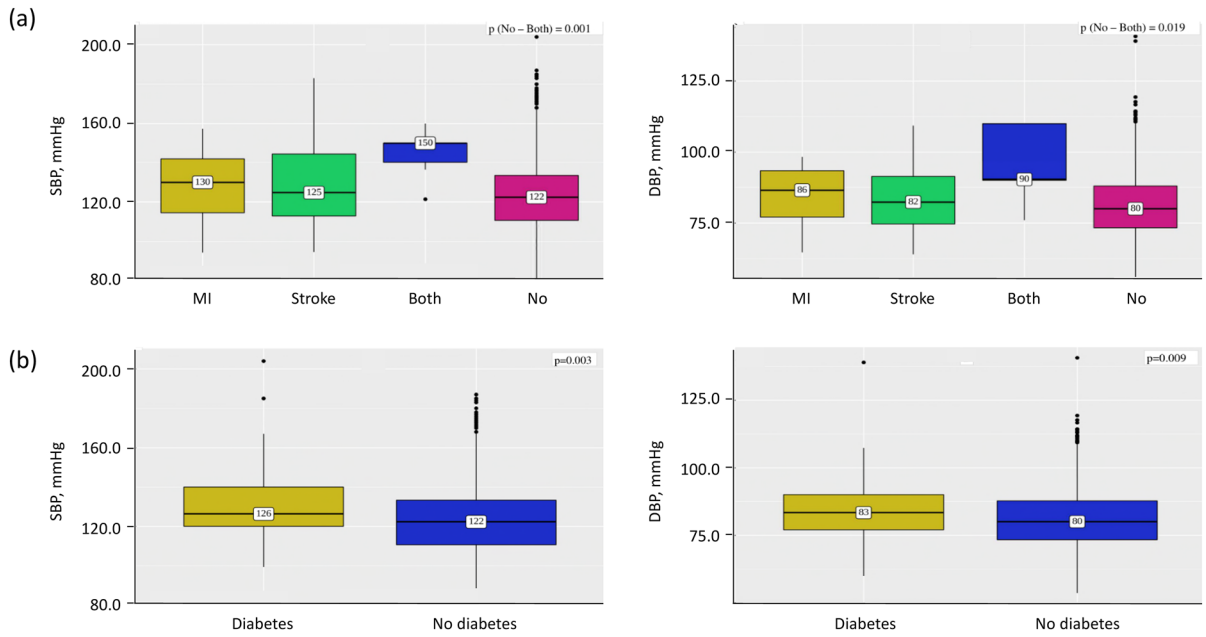

Fig. 4 Boxplot of SBP and DBP in participants with previous MI (**a**), stroke and/or both or neither, and in participants with diabetes or no diabetes (**b**) in the 2021 survey. Boxplots show the mean ± 95% confidence interval, with minimum and maximum values depicted as vertical lines. *DBP* Diastolic blood pressure, *MI* myocardial infarction, *SBP* systolic blood pressure

respectively; $p < 0.01$; Fig. 4b). Again, results from 2022 and 2023 were similar in this regard.

Using 2021 data, analyses of the age- and sex-adjusted logistic regression model confirmed that older age, male sex and high BMI were risk factors for high SBP/DBP ($p < 0.001$; Table 3). Women who reported a history of AH during previous pregnancy had significantly higher SBP and DBP than those with no such history (ESM Fig. S1). There were no

Table 3 Logistic regression analysis: association of selected factors with high blood pressure (≥ 140/90 mmHg; 2021 survey)

Factors	Crude		Adjusted[a]	
	OR (95% CI)	*p* value	aOR (95% CI)	*p* value
Obesity (BMI ≥ 30 kg/m²)				
SBP	2.9 (2.3–3.9)	< 0.001	1.8 (1.3–2.4)	< 0.001
DBP	3.2 (2.5–4.0)	< 0.001	2.3 (1.8–2.9)	< 0.001
Male sex				
SBP	1.1 (1.1–1.1)	< 0.001	1.1 (1.1–1.1)	< 0.001
DBP	2.1 (1.7–2.6)	< 0.001	2.1 (1.7–2.6)	< 0.001
Age				
SBP	1.1 (1.1–1.1)	< 0.001	1.1 (1.1–1.1)	< 0.001
DBP	1.0 (1.0–1.0)	< 0.001	1.0 (1.0–1.0)	< 0.001
Alcohol consumption (1–6 times a week)				
SBP	1.6 (1.2–2.0)	< 0.001	1.3 (0.9–1.7)	0.072
DBP	1.4 (1.1–1.8)	0.003	1.1 (0.9–1.5)	0.278
Smoking (current + previous)				
SBP	1.1 (0.8–1.4)	0.614	0.9 (0.7–1.2)	0.384
DBP	1.0 (0.8–1.3)	0.731	0.9 (0.7–1.1)	0.182

aOR Adjusted odds ratio, *BMI* body mass index, *CI* confidence interval, *DBP* diastolic blood pressure, *OR* odds ratio, *SBP* systolic blood pressure

[a]Adjusted for sex and age

statistically significant associations between BP levels and alcohol consumption and smoking (Table 3). Similar findings were obtained with respect to 2022 and 2023 data (ESM Tables S1, S2).

DISCUSSION

In this study, we report the findings of one of the largest AH screening initiatives in Kazakhstan. Key findings include: (1) a notable decline in the proportion of participants who had never had their BP measured (27% in 2021 vs. 12% in 2023); (2) a high AH prevalence (37–45%), with key risk factors being older age, male sex, and high BMI; (3) a trend towards increasing AH awareness, from 50% in 2021 to 66% in 2023; (4) a significant gap in BP control, whereby although 68–91% of aware individuals were on treatment, fewer than 50% achieved BP < 140/90 mmHg and only 15–16% met the stricter < 130/80 mmHg target.

Consistent with our findings, 32% of participants in the 2019 global MMM study reported having BP measured for the first time [10]. A global correlation was observed between BP measurement rates and national income [10]. The decline in first-time BP measurement in our study may reflect differences in study sites, as screenings in 2022–2023 were limited to Almaty, where healthcare access is higher [11].

The 37% AH prevalence in Kazakhstan's MMM 2021 survey aligns with global MMM estimates (35%) [6] and the World Health Organization's 2023 AH report (42%) [12]. Similar to previous MMM campaigns [6, 10, 13, 14], we confirmed higher BP in men, older adults and those with high BMI. However, the findings in global data, the findings of Kazakhstan's MMM 2021 survey found that smoking and alcohol consumption were not significantly associated with BP, possibly due to underreporting.

AH prevalence in Almaty (45%) was significantly lower than the 70% reported in Nur-Sultan in 2012–2013 [9]. While national reports suggest increasing AH prevalence [5], our findings imply that earlier estimates may have been influenced by selection bias, as in the 2012–2013 study, BP was measured only in outpatient clinics in Nur-Sultan.

In line with global MMM 2021 data, approximately 50% of hypertensive participants in 2021 were aware of their condition [6]. Awareness often correlates with education and socioeconomic status [9], explaining regional disparities [6]. The rise in awareness (to 70%) in 2022–2023, when screenings were conducted in Almaty, and the high awareness in Nur-Sultan (91%) in 2012–2013 [9], may reflect differences in healthcare access and health literacy [15].

Overall, the findings of our study are consistent with the results of the global MMM 2021 and Nur-Sultan studies in that

while the majority of AH-aware participants received hypertensive medication, only up to half of those on antihypertensive therapy were controlled to the conservative BP target of < 140/90 mmHg. When we used the lower BP target of < 130/80 mmHg as the definition of control, which more accurately reflects current guidelines [16–20], the control rate among those treated in 2021–2023 decreased to 15–16%. Factors that could be contributing to low rates of BP control include poor adherence to antihypertensive therapy, lack of general knowledge about the importance of BP control and failure of healthcare providers to intensify treatment to achieve BP control as appropriate.

Poor treatment adherence was identified as a problem in this study, particularly in younger hypertensive participants. This may reflect limited access to free medications and lack of knowledge about the risks of high BP and the importance of taking medication as prescribed to control BP. Furthermore, of those taking medication, more than one-third were only on a single therapy in all 3 years of the survey, despite the latest European Society of European Society of Hypertension (ESH) guidelines recommending initiation of drug treatment with two antihypertensive medications to achieve effective BP control [20]. As pointed out in the global MMM survey [6], there is significant scope for improvement of BP control with single-pill combination therapies as advised by AH guidelines in use during the 3 years of the campaign [18, 20].

The study highlights significant gender and age-related disparities in AH awareness and BP control. Awareness levels were consistently higher among female patients compared to male patients, with a significant upward trend over the years. However, despite this improvement, BP control remained suboptimal, particularly among men and younger adults. Age was strongly associated with awareness, with older individuals demonstrating significantly higher awareness and better BP control than younger age groups. Nevertheless, strict BP control (< 130/80 mmHg) remained low across all groups, underscoring the need for more aggressive intervention strategies to improve adherence to treatment and BP management.

Furthermore, findings suggest that barriers to effective secondary prevention—including limited access to high-quality antihypertensive medications under the state-guaranteed benefit package in Kazakhstan—may contribute to inadequate BP control. The predominance of low-quality generic drugs distributed through public healthcare services could explain the persistent treatment gaps, especially among high-risk patients with a history of MI, stroke, and diabetes.

These results emphasize the need for improved access to effective antihypertensive medications, better patient education programs and enhanced treatment strategies tailored to vulnerable populations. Future efforts should focus on addressing non-adherence due to medication unavailability, affordability issues and the need for stricter clinical follow-up to optimize AH control and reduce cardiovascular risk.

This study had several limitations. Most importantly, the true prevalence of AH in Kazakhstan could not be evaluated because a nationally representative sample was not targeted. Kazakhstan has 14 regions, but the study included only four cities from the south, center and east of country in 2021, and only one large city in 2022 and 2023. Further nation-wide studies that include rural areas are needed. A study focused solely on urban populations may not accurately reflect the overall AH burden, as rural residents experience different healthcare access, lifestyle factors, and treatment barriers. Urban populations generally have better healthcare access, higher health literacy level and more frequent screenings, leading to greater awareness and treatment adherence. However, city dwellers also face higher stress levels, have relatively sedentary lifestyles and consume higher quantities of processed foods, which may contribute to AH. City dwellers benefit from better medication availability and specialist care, whereas rural populations struggle with limited access, long travel distances and higher costs, leading to lower treatment rates. Also, AH was identified using a single set of three measurements taken on a potentially high-stress occasion. This is not recommended diagnostic practice [19, 20], and

may lead to a high proportion of false positives [14]. Additionally, half of the BP measurements were taken in medical settings, which may result in the self-selection of a greater proportion of participants with AH [13]. It is therefore possible that our results overestimated AH prevalence due to white coat AH or stress, and that it missed increased BP that in some can only be found during continuous monitoring (masked AH). Nonetheless, the primary aim of the study was to raise awareness of the importance of annual BP measurement in a large cohort of people. We were able to identify individuals with increased cardiovascular risk and suspected AH, who could be further referred for 24-h BP monitoring.

CONCLUSION

The findings of this study confirm that untreated and inadequately treated AH is problematic in Kazakhstan. The results highlight the need for programs aimed at increasing awareness of the risks of AH, and the importance of regular BP measurement and adherence to guideline-directed antihypertensive therapy for effective BP control and reduction of cardiovascular risk.

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Data Availability. Permission was obtained to access and use the data utilized in this study. The data are not publicly available, as they were collected specifically for the purposes of the May Measurement Month campaign in Kazakhstan with appropriate ethical approvals.

Declarations

Conflict of Interest. Dilyara M Mukhtarkhanova, Gulnara A Junusbekova, Meiramgul K Tundybayeva, Tatyana N Leonovich, Lyazat S Baglanova, Eldar M Ismailov and Sabina B Samitova have no conflicts of interest to declare.

Ethical Approval. The study was approved by the "Kazakh National Medical University

named after S. Asfendiyarov" ethics committee (decision No. 8(114)) on 30 June 2021. The study was conducted in accordance with the Declaration of Helsinki of 1964 and its later amendments. Informed consent was obtained from all participants for both participation in the study and publication of the data.

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