Check for updates

ARTICLE

Prevalence of high blood pressure and cardiovascular risk factors from a community screening programme in the Middle-East; a 3-year analysis of data from the May Measurement Month programme (2017–2019) in Oman

Hassan Al-Riyami[1], Ibrahim Al-Shezawi[1], Suhaib Al-Mashari[2], Adil Al-Riyami[3], Hatim Al-Lawati[3], Hafidh Al-Hadi[3], Benny Panakkal[4], Shafeek Mohammed[4], Muhammad M. Shaikh[3], Thomas Beaney [5,6], Neil R. Poulter[5] and Sunil K. Nadar [3 ✉]

The May Measurement Month (MMM) programme is a global cross-sectional blood pressure (BP) screening programme. Here we present the combined data for the years 2017–2019 from Oman. BP was measured at various screening sites, according to standard protocol and hypertension was diagnosed if the BP was ≥140/90 mmHg or if the individual was already on antihypertensive medication. A total of 15,679 individuals (mean age 41.1 ± 12.6 years range 18–89 years; 71% male) were screened over the 3-year period. 7702 individuals (mean age 41.8 ± 13.9 years; 71.5% male) had three BP readings. The mean of the last two BP readings was 127.3 ± 17.1 mmHg. 1573 readings were in the hypertensive range (1004 newly diagnosed hypertension). A further 749 individuals were on antihypertensive medications with normal BP readings giving a proportion of 30.1% of the entire cohort being hypertensive. BP was high in 43% of patients on antihypertensive medications, 28.1% of those with previous myocardial infarction, 33.9% of those with previous stroke and 37.6% of the diabetic patients. BP strongly correlated with body mass index (BMI) and age (both $p < 0.001$), with a large proportion (68.5%) of individuals having high BMI(>25 kg/m^2). Arab and South Asian ethnicity was associated with higher BMI and BP (both $p < 0.001$).Community screening programmes help identify previously undiagnosed hypertension and hypertensives with high BP. They also help to identify those at high cardiovascular risk. More emphasis should be given to monitoring those in high cardiovascular risk categories and high-risk ethnic groups.

INTRODUCTION

Hypertension is a major cardiovascular risk factor that is accountable for more than 10% of deaths globally [1, 2]. Despite projections that by the year 2025, there will be more than 1.5 billion people worldwide suffering from hypertension [3] it is likely that this number is an underestimation as the majority of the patients suffering from high blood pressure (BP) are asymptomatic and have never had their BPs measured. Indeed, in many instances, the diagnosis of hypertension is made when the patient presents with a stroke or a myocardial infarction(MI), leading to hypertension often being referred to as the 'silent killer' [3].

In many western countries, the prevalence of hypertension appears to have stabilised, but in other parts of the world, especially in developing countries, the prevalence appears to be increasing [4]. The reasons for this increasing prevalence are many. Improved access to health care in many countries has led to increased screening of patients and hence a higher rate of pick up of previously undiagnosed hypertension. In addition, increasing

longevity, changing lifestyles and the increasing 'westernisation' and urbanisation of developing countries contributes to increasing BPs.

As raised BP is often asymptomatic, screening programmes and regular health checks are essential to help pick up previously undiagnosed patients with hypertension. May Measurement Month (MMM) is one such initiative that was started by the International Society of Hypertension and was first run in 2017 [5]. The aim of this campaign was to improve awareness of the dangers of high BP and to motivate people to check their BP on a regular basis. In the first year, more than 1.2 million individuals from more than 80 countries had their BP checked. The screening took place by the help of trained volunteers to measure BP according to a standard protocol. Following on from the success of the programme, there were plans for it to be conducted annually. It was run in 2018 and 2019, but not in 2020 due to the COVID-19 pandemic and the subsequent lockdown and social distancing measures that made such a mass screening

[1]Directorate of Nursing, Sultan Qaboos University Hospital, Muscat, Oman. [2]Department of Clinical Physiology, Sultan Qaboos university Hospital, Muscat, Oman. [3]Department of Medicine, Sultan Qaboos University Hospital, Muscat 123, Oman. [4]Department of Medicine, Badar Al-Samaa Hospital, Ruwi, Muscat, Oman. [5]Imperial Clinical Trials Unit, Imperial College London, Stadium House, 68 Wood Lane, London, UK. [6]Department of Primary Care and Public Health, Imperial College London, St Dunstan's Road, London, UK. ✉email: sunilnadar@gmail.com

programme difficult to conduct. There are plans for it to be conducted again in 2021 in countries where it can be run safely with the COVID-19 precautions. Overall, the programme screened around 4.2 million individuals, from more than 100 countries, making this the world's largest public BP screening programme ever [6, 7]. The countries involved in the MMM programme are ethnically geographically and economically diverse giving a wide perspective on the global burden of high BP [5–7].

Oman is a country situated in the eastern part of the Arabian peninsula with an estimated population of around 4.8 million of which around 40% are expatriate workers [8, 9]. Due to its rich history of interaction with neighbouring and distant countries in Asia and Africa that goes back many thousands of years, the Omani population is ethnically diverse. The country is vast, but majority of the population lives in the capital city of Muscat and the surrounding province of north Al-Batinah. It has a relatively young population with the median age currently at 25.6 years and 30% of the population being below 14 years of age [8]. It has a fairly modern health care system with a low prevalence of infectious diseases similar to those in the west. With increasing affluence and modernisation, non-communicable diseases and risk factors such as obesity and low levels of exercise are of increasing importance.

According to WHO estimates, around 17% of the adult population aged 18 years and above in Oman are hypertensive [10]. A previous study from Oman reported an incidence of hypertension of around 27% with hypertension being responsible for around 68% of adult patients who present with an acute coronary syndrome [11, 12]. Oman participated in all three iterations of the MMM programme. In this report, we present the cumulative data from Oman for the 3 years that it participated (2017–2019).

METHODS

MMM was a cross-sectional screening programme for BP among the adult population aged 18 years or over, in Muscat, Oman. Ethical approval was obtained from the Medical Research Ethics committee of the Sultan Qaboos University Hospital and the study was conducted in accordance with the Declaration of Helsinki. Extensions to the original ethical approval were obtained each year. The nature of the survey was explained and verbal consent was obtained from all the participants before proceeding.

Screening sites were set up at various locations in the Sultan Qaboos University Hospital, and at seven branches of the Badar Al Samaa private hospitals in Muscat. A convenience sampling method was employed with public screening events held at shopping malls, parks and workplaces of the volunteers. There were around 40 volunteers who helped with this survey. These were mainly hospital nursing and allied health staff, who were trained to take BP according to the study protocol. The recruitment period for this study ran from the 1st of May to the 31st of May on three consecutive years i.e., 2017, 2018 and 2019.

All individuals above the age of 18 were invited to check their blood pressure. Verbal informed consent was obtained, and BP was measured as per the standard protocol of the MMM programme. Subjects had to be seated for at least 5 min before the BP was measured at the arm closest to the table (depending on how the subjects were seated). Three BP measurements were taken at 1-min intervals. The volunteers were given training and briefed about the study protocol and were observed taking BP before being allowed to check the BP for the study. The majority of the readings were obtained using the automated Omron Healthcare machines. In some of the sites, an A&D™ aneroid apparatus was used. BP was calculated as the mean of the second and third readings. As per the European Society of Hypertension guidelines a subject was considered to be hypertensive if their systolic BP was ≥140 mmHg or diastolic BP ≥ 90 mmHg if they were already on antihypertensive medication [13]. The term "High blood pressure" was also used to refer to BP in the hypertensive range as defined above for those already on antihypertensive medications.

In addition to the BP readings, personal data including demographics and cardiovascular risk factors were obtained. History of cardiovascular risk factors such as diabetes, hypertension, previous strokes and heart attacks were self-reported in accordance with the study protocol. In view of the

scale of the screening project, confirmation of these factors was not possible. The height and weight of the patients were also self-reported. In cases where the patient was not sure, a calibrated weighing scale and height measurement scale were available for use. Body mass index was calculated according to the formula (weight in kilograms/(Height in metres)^2. Information on educational and employment status was not collected.

Ethnicity was also self-reported as the ethnicity that the individual perceived themselves to be, and no nationality data were collected. Individuals from India, Bangladesh, Srilanka and Pakistan were included as South-Asians, whilst those from other eastern Asian countries such as Philippines, China, Thailand were classed as East-Asians. The data were submitted to the central team via the specialised MMM app and via a specially created Microsoft Excel file.

The data were analysed initially as part of the global strategy and individually for each country. The analysis for this paper was done locally by the team in Oman. The collected data were analysed using statistical software SPSS Statistics (SPSS Inc., Chicago, US) version 22. A descriptive analysis of the categorised variables was presented as proportions, and continuous variables were presented as the mean and standard deviation. Students t test and Chi-square test were used to check for differences among groups for normally distributed variables and for categorical variables respectively. Pearson's coefficient of corelation was used to check for correlation between normally distributed variables. Bivariate analysis was used to check the risk of being hypertensive with the demographic and other risk factors being used as predictors.

RESULTS

A total of 15,679 individuals (mean ± SD age 41.1 ± 12.6 years; 11,182 (71%) male) were screened over the 3-year period. The number of individuals screened was 934 in 2017, 12,688 in 2018 and 2057 individuals in 2019. The majority of participants were of Arab ethnicity (74.8%). Around a fifth of the population (19.2%) were on antihypertensive medications. The baseline characteristics of the screened population over the 3 years are given in Table 1.

Out of the whole screened population, 7702 individuals (mean age 41.8 + 13.9 years; 5507 (71.5%) male) had three BP readings. This included 931 (mean age 44.1 + 15.1 years, 54.2% male) from 2017, 4739 (mean age 40.8 + 14.3 years; 72.5% male) from 2018 and 2031(mean age 42.9 ± 12.2 years; 76.8% male) from 2019. The average of the first SBP reading for those who had three readings ($n = 7702$) was 131.37 ± 18.8 mmHg whilst the average of the second reading was 128.21 ± 17.6 mmHg and the average of the third reading was 126.57 ± 17.21 mmHg, the difference being highly statistically significant ($p < 0.001$). The mean of the last two BP readings was 127.3 ± 17.1 mmHg whilst the mean of three readings was 128.6 ± 17.3 mmHg, which again was significant. Table 2 gives the year-wise distribution of the mean BP. If we used only the first BP readings, the proportion of hypertensive patients would be 38.9%, 37.5%, 38.4% as compared to 33.1%, 30.3% and 29.5% for the average of the last two readings in 2017, 2018 and 2019 respectively, the difference being statistically significant.

Further analysis was performed only on those individuals with three BP readings. Out of the 7702 who had three readings, 1573 individuals had BP readings within the hypertensive range (≥140/90 mmHg) There were a further 749 individuals on antihypertensive medications who had BP readings in the normal range. Therefore, the total number of hypertensive individuals in this cohort was 2322 giving a proportion of 30.1% of the screened population. Table 3 categorises the BP in the various groups. Patients in higher age category had significantly higher blood pressures [Fig. 1]. There was no difference between the genders. Patients on antihypertensive mediations, diabetic patients and those with previous MI or CVA had higher BPs than those without these risk factors. There was no difference in BP between those who were fasting and those who were not fasting. Patients with high BMI had higher BP. Of those who were on antihypertensive medications, 569 out of 1310 (43%) had high BP (on treatment

Table 1. Year-wise distribution of the screened individuals.

	2017 (n = 934)	2018 (n = 12,688)	2019 (n = 2057)	Combined (n = 15,679)
Age (years)	44.2 ± 15.1	40.5 ± 12.4	42.8 ± 12.2	41.1 ± 12.6
Sex				
Male	506 (53.9%)	9094 (71.6%)	1582 (76.9%)	11,182 (71.3%)
Female	428 (46.1%)	3594 (28.4%)	475 (23.1%)	4497 (28.7%)
Ethnicity				
Arab	826 (88.4%)	6508 (73.3%)	1540 (75.5%)	8863 (74.8%)
South Asian	74 (7.9%)	321 (3.6%)	383 (18.7%)	778 (6.5%)
East Asian	33 (3.5%)	560 (6.3%)	85 (4.1%)	678 (5.7%)
Caucasian	1 (0.2%)	1479/8868 (16.8%)	31/2039 (1.7%)	1511 (12.7%) (total: 11841[a])
Diabetic	162 (17.3%)	879/9928 (8.8%)	218 (10.5%)	1259/12,919 (9.7%)
On antihypertensive medication	142 (15.2%)	1810/9104 (19.8%)	373 (18.1%)	2325/12,095 (19.2%)
Smoker	59 (6.3%)	1677/9921 (16.9%)	122/2041 (5.9%)	1858/12,896 (14.4%)
Previous MI	23 (2.4%)	158/9437 (1.6%)	26/2034 (1.2%)	207/12,405 (1.6%)
Previous CVA	10 (1.1%)	346/8810 (3.9%)	16/2024 (0.7%)	372/11,768 (3.1%)
Pregnant	14/428 (3.2%)[b]	40/3594 (1.1%)	11/475 (2.3%)	65/4497 (1.4%)

MI myocardial infarction, *CVA* cerebrovascular accident.
[a]The totals in each group may not add up to the total number of patients due to missing/incomplete data.
[b]Percentage of female participants.

Table 2. Blood pressure readings over 3 years.

	2017	2018	2019	Total
Three BP readings available (n)	932	4739	2031	7702
Average of three SBP readings (mmHg)[a]	131.4 ± 19.7	128.1 ± 17	128.5 ± 16.6	128.6 ± 17.3
Average of second and third SBP readings where available (mmHg)	130.4 ± 19	126.8 ± 16.8	126.9 ± 16.6	127.3 ± 17.1
Average of three DBP readings (mmHg)	80.3 ± 10.8	79.6 ± 11.1	80.4 ± 11	79.9 ± 11.1
Average of second and third DBP readings where available (mmHg)	80.3 ± 11.1	80.7 ± 11.5	81.0 ± 11.4	80.8 ± 11.4
Number in hypertensive range using the average of second and third readings	264 (28.3%)	963/4739 (20.3%)	377 (18.5%)	1604 (20.8%)
Total number diagnosed as having HT[b]	308 (33.1%)	1436 (30.3%)	601 (29.5%)	2345 (30.4%)
Number in hypertensive range using only first BP readings[a]	326 (34.9%)	3010/9103 (33.7%)	611 (29.7%)	3947 (32.6%)
Total number having HT using only first reading[ca]	363 (38.9%)	3418 (37.5%)	785 (38.4%)	4566 (37.8%)

BP blood pressure, *SBP* Systolic blood pressure, *DBP* Diastolic blood pressure, *HT* hypertension.
[a]Of the entire population where data were available (n = 12,073).
[b]Average of second and third BP readings in the hypertensive range and those on antihypertensive medications but with controlled BP.
[c]Total of first BP reading in the hypertensive range and those on antihypertensive medications but controlled BP.

and systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg). Similarly of the high-risk groups, 42 out of 149 patients (28.1%) with previous MI, 111 out of 327 individuals (33.9%) with previous CVA and 359 out of 953 individuals (37.6%) with diabetes had BP in the hypertensive range. These findings are summarised in Table 4.

The main ethnic group in our cohort were patients of Arab origin (either Omani citizens or those from other neighbouring countries, notably Egypt) accounting for nearly 75% of the cohort. Self-reported ethnic background and not nationality data were collected. Table 5 shows the difference in demographics and BP control based on ethnicity. The BMI was highest in the Arab and South Asian participants and lowest in the other groups. Similarly, the Arabs had the highest proportion of people in the obese category (27%) whilst the East-Asians had the lowest number of obese individuals. BP was also highest in the Arabs and South-Asians, while the East -Asians had the lowest.

The average BMI of the males in out cohort was 26.7 ± 4.6 and for the females, it was 26.98 ± 4.77 suggesting that the average

BMI is in the overweight category. Additionally, 4914 out of 7774 males (63.2%) and 3068 out of 3837 females (79.9%) were either overweight or obese, with a very high proportion of women (51.9%) being obese. Table 6 shows the distribution of the cardiovascular risk factors and BP among the different BMI categories. The BMI increased with the age of the patients. With increasing BMI, there was a higher number of patients with diabetes, and those already on antihypertensive medications. There was a high proportion of patients in the low BMI group who had diabetes, previous MI and previous stroke. This included 11 patients with type 1 diabetes. The BP increased with increasing BMI with the overweight and obese categories having significantly higher BP than the normal and low BMI groups ($p < 0.001$) [Fig. 2]. The proportion of individuals with BP in the hypertensive range and those with hypertension also increased with increasing BMI.

By Pearsons coefficient of correlation, SBP correlated strongly with age ($r = 0.32$, $p < 0.001$) and BMI ($r = 0.21$, $p < 0.001$) and DBP also corelated strongly with age ($r = 0.20$, $p < 0.001$) and BMI ($r = 0.195$, $p < 0.001$). By bivariate analysis, the predictors of being

Table 3. Analysis based on the average of the second and third readings in individuals with three BP readings.

	SBP (mmHg)	P value	DBP (mmHg)	P value
Sex				
Male (5505)	127 ± 17.1	0.14	79.6 ± 11	<0.001
Female (2042)	126.8 ± 17.6		78.2 ± 11.2	
On HT medications				
Yes (1321)	138.1 ± 18.7	<0.001	83.3 ± 11.9	<0.001
No (6341)	125.0 ± 15.9		78.4 ± 10.6	
Diabetic				
Yes (958)	135.2 ± 18.5	<0.001	80.7 ± 11.1	<0.001
No (6691)	126.1 ± 16.6		79.0 ± 11	
Previous MI				
Yes (150)	131.32 ± 19	0.004	79.1 ± 10.6	0.9
No (7508)	127.1 ± 17.1		79.2 ± 11	
Previous CVA				
Yes (330)	133.2 ± 17	<0.001	81.5 ± 8.5	<0.001
No (7312)	127.1 ± 17.1		79.1 ± 11.1	
BMI (kg/m^2)				
<18.5 (131)	119.3 ± 15.3	<0.001*	73.6 ± 10.1	<0.001*
18.6–24.9 (1890)	122.5 ± 16.4		76.4 ± 10.5	
25–29.9 (3095)	128.3 ± 17.1		80.1 ± 10.6	
>30 (2110)	130.9 ± 16.9		81.8 ± 11.0	
Age (years)				
18–30 (1739)	120.1 ± 13.5	<0.001*	73.6 ± 10.1	<0.001*
30–40 (2081)	124.2 ± 15.1		79.6 ± 10.2	
40–50 (1934)	129.1 ± 17.3		82.4 ± 11.1	
50–60 (1186)	134.1 ± 17.8		82.1 ± 10.7	
>60 (757)	137.1 ± 18.1		78.3 ± 10.9	
Fasting				
Yes (2983)	127.4 ± 17.0	0.7	79.5 ± 10.9	0.3
No (4715)	127.1 ± 17.2		79.1 ± 11.1	

Numbers for each group are given within brackets.
SD standard deviation, *MI* myocardial infarction, *CVA* cerebrovascular accident, *BMI* body mass index, *HT* hypertension, *SBP* systolic blood pressure, *DBP* diastolic blood pressure.
Analysis by chi-square test except * which is by one-way ANOVA.
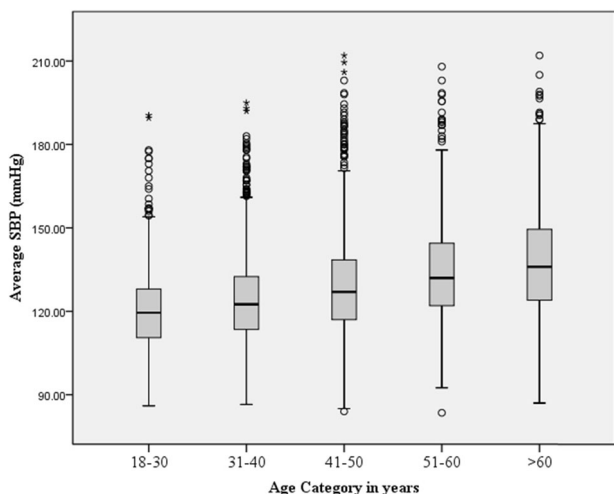

Fig. 1 The average blood pressure among the different age groups. SBP: Systolic blood pressure.

Table 4. Number of individuals where BP falls in hypertensive range using the average of second and third BP readings.

	Number with BP in hypertensive range	Total	Percentage
Male	1139	5469	20.8%
Female	434	2035	21.3%
On Hypertensive medications	569	1310	43.4%
Diabetic	359	953	37.6%
Previous MI	42	149	28.1%
Previous CVA	111	327	33.9%
BMI			
<18.5 kg/m^2	15	131	11.4%
18.6–24.9 kg/m^2	258	1890	13.6%
25–29.9 kg/m^2	696	3095	22.4%
>30 kg/m^2	551	2110	26.1%

BP blood pressure, *MI* myocardial infarction, *CVA* cerebrovascular accident, *BMI* body mass index.

Table 5. Effect of ethnicity on blood pressure and comorbidities.

	Arab (*n* = 8636)	South Asian (*n* = 777)	East Asian (*n* = 648)	Caucasian (*n* = 1457)	*P* value
Age (years)	40.5 ± 13.4	40.4 ± 10.3	40.1 ± 9.3	45.3 ± 12/5	<0.001**
Sex					
Male	6336 (73.3%)	592 (76.1%)	475 (73.3%)	1063 (72.9%)	0.3***
Female	592 (26.7%)	176 (23.9%)	173 (26.7%)	394 (27.1%)	
Diabetic	1011 (11.7%)	39 (5.1%)	64 (9.8%)	31 (2.1%)	<0.001***
On antihypertensive medications	1591 (18.4%)	81 (10.4%)	44 (6.7%)	484 (33.2%)	<0.001***
BMI (kg/m^2)	27.36 ± 4.91	26.95 ± 4.06	25.7 ± 2.8	25.27 ± 3.6	<0.001***
BMI category					
Underweight	135 (1.5%)	8 (1%)	4 (0.6%)	36 (2.4%)	<0.001***
Normal	2346 (27.2%)	183 (23.5%)	232 (35.8%)	556 (38.1%)	
Overweight	3609 (41.7%)	382 (49.1%)	379 (58.4%)	711 (48.7%)	
Obese	2341 (27.1%)	157 (20.2%)	51 (7.8%)	165 (11.3%)	
Average SBP(mmHg)[a]	127.1 ± 16.9	127.4 ± 18.1	123.5 ± 17.0	125.5 ± 17.2	<0.001**
Average DBP(mmHg)[a]	78.9 ± 11.02	79.7 ± 11.1	79.3 ± 10.7	81.3 ± 10.2	0.04**
BP in hypertensive range[b]	1355 (15.6%)	126 (16.2%)	13 (2%)	10 (0.6%)	0.009***

BMI body mass index, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *BP* blood pressure.
[a]The average of the second and third reading where three readings are available.
[b]Where SBP > 140 mmHg and/or DBP > 90 mmHg.
**Analysis by one-way ANOVA; ***Analysis by chi-square test.

hypertensive were age (*p* < 0.001), smoking (*p* < 0.001) and BMI (*p* < 0.001).

DISCUSSION

Our survey demonstrated that in Oman, the proportion of our screened unselected general population having hypertension (i.e. those who are already on antihypertensive treatment and those not previously known to have hypertension, but now have BP in the hypertensive range) between 2017 and 2019 inclusive is around 30% which is in keeping with the WHO fact sheet and other studies [10, 12]. As mentioned later in the limitations, this could be influenced by a sampling bias with this population being younger and healthier than the general population. Interestingly in our survey, two-thirds of those with high BP were diagnosed as having hypertension for the first time. Among those who were already on antihypertensive medications, just under half had BP that was uncontrolled. Even among the high cardiovascular risk groups the control rates were not optimal with almost half of these patients with pre-existing cardiovascular disease having BP in the hypertensive range.

BP control has always been a major issue in the management of hypertensive patients. Studies from other countries have also shown similar rates of uncontrolled hypertension in patients on antihypertensive medications. Melgarejo et al studied more than 6000 subjects from around 3 continents and found a control rate of around 38.6% (10.1–55.3%) in their study for conventional BP measurements and around 45.6% (18.6–64.2%) for ambulatory measurements [13].

The outlook, however, is more positive. A recent analysis by the non-communicable disease (NCD) risk factor collaboration compared control rates among different countries and the changes with time [1, 2]. They found that over the last 40 years or so, the control rates for hypertension have improved. In the 1980s and early 1990s, the proportion of patients on antihypertensive medications that had controlled BP (less than 140/90 mmHg) was around 20% in most countries. This rate had increased over the following decade and has since plateaued from the mid-2000s onwards. The current rate of controlled BP among hypertensives is quite high in countries such as Canada, South Korea, USA and

Germany at around 70%. In many other countries such as Spain, Finland and Italy, however, the control rates are low at around 20–30% [14].

Our study also confirms the importance of having at least three blood pressure readings and measuring the average of the second and third reading as recommended by the guidelines [15]. The number of patients in the hypertensive range fell dramatically when the first reading was ignored. Many mass screening campaigns and office screening programmes in the past have relied on a single BP reading due to time constraints and the large number of people to be screened. However, the MMM protocol made it clear that only those with three BP readings would be included in the final analysis as this can alter the prevalence rates greatly.

The Islamic holy month of Ramadan fell during the later part of May 2018 and most of May 2019. During this month, most of the Omani population fast during the day time. It is thought that fasting could affect adherence to medication and thereby blood pressure. However, we did not find any significant difference in blood pressures between 2017 when there was no fasting and the other years. Similarly, there was no difference in BP between those who were fasting and those who were not fasting, although they represent totally different patient groups and cannot be compared directly. This is similar to the findings from the overall global MMM data for 2018 and 2019 where non-significant differences were found between those who were fasting and those who were not fasting [6, 7]. Although we did not question the participants about adherence to medications during fasting, it appears that they were adherent during this time.

Other interesting findings from our study include those regarding BMI and ethnicity. As expected, the BP corelated strongly with the BMI and age with the BP increasing with increasing BMI and age. These are both known to be strong predictors of BP and cardiovascular risk and indeed those with higher BMI had higher prevalence of cardiovascular risk factors [2]. Those with higher BMI also had a higher proportion of people with BP in the hypertensive range. This highlights once again the importance of weight reduction in the control of BP and the overall reduction of cardiovascular risk.

The average BMI for the whole cohort was in the overweight category. Obesity is a major health concern in the Arabian gulf

Table 6. Effect of body mass index (BMI) on blood pressure and comorbidities.

	Low BMI (n = 201)	Normal BMI (n = 3428)	Overweight BMI (n = 5193)	Obese BMI (n = 2716)	P value
Age(years)	32.7 ± 13.3	29.4 ± 13.6	42.8 ± 12.4	42.7 ± 12.1	<0.001*
Sex					
Male	147 (1.8%%)	2713 (34.8%)	4117(52.9%)	797(10.2%)	0.004**
Female	54(1.4%)	715(18.6%)	1076(27.9%%)	1992(51.9%)	
On antihypertensive medications	15(7.4%)	484(14.1%)	1054(20.2%)	723(26.6%)	<0.001**
Diabetes	11(5.4%)	281(8.1%)	546(10.5%)	376(13.8%)	<0.001**
Previous MI	10(4.9%)	64(1.8%)	85(1.6%)	43(1.5%)	0.004**
Previous CVA	10(4.9%)	153(4.4%)	148(2.8%)	54(1.9%)	<0.001**
Average SBP(mmHg)[a]	119.2 ± 15.3	122.1 ± 16.7	128.6 ± 17.2	130.4 ± 16.9	<0.001**
Average DBP(mmHg)[a]	73.3 ± 10.1	76.4 ± 10.5	80.1 ± 10.6	81.8 ± 11.1	<0.001**
Number with BP in hypertensive range	15(7.4%)	258(7.5%)	696(13.4%)	551(20.2%)	<0.001**
Number of hypertensives[b]	21(10.4%)	381(11.1%)	1011(19.4%)	831(30.5%)	<0.001*

Low BMI—<18.5 kg/m^2 Normal BMI—18.6–24.9 kg/m^2; overweight BMI—25–29.9 kg/m^2; obese BMI > 30 kg/m^2.
Values are number (percentages) unless specified.
MI myocardial infarction, *CVA* cerebrovascular accident, *SBP* systolic blood pressure, *DBP* diastolic blood pressure.
*Analysis by one-way ANOVA ** Analysis by chi-square test.
[a]Average of the second and third blood pressure readings where three readings are available.
[b]Sum of those with BP in hypertensive range and those on antihypertensive medications but normal BP.
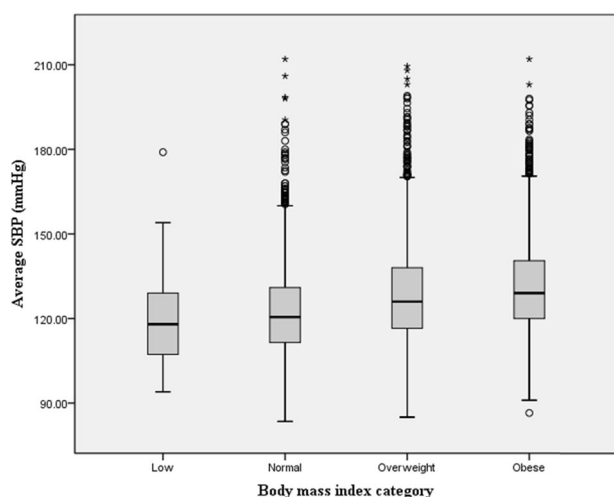

Fig. 2 The average systolic blood pressure in the different BMI categories. SBP- Systolic blood pressure; BMI- Body mass index.

countries. The BMI increased with age and interestingly most of those in the obese category were females. This could be due to cultural reasons in the region, where men take part in sports and other outdoor activities, while such opportunities for women and the older age groups are restricted [16]. The hot summers also restrict outdoor activities with most people having to stay indoors during these months [16]. The governments in the region have undertaken many initiatives to try and tackle obesity [16]. Recently the government of Oman introduced extra taxes for sugary drinks and various other projects have been undertaken to increase the amount of exercise taken by the citizens and residents [17]. Despite this, studies have demonstrated that the amount of exercise undertaken by many, including young adults and teenagers and especially women is low [18].

There were also clear differences between the different ethnic groups. Whilst most of the participants were of Arab ethnicity, there were a sizeable number of other ethnic groups. Those of Arab ethnicity had the highest BMI and highest BP readings along with those of South- Asian origin. Those of East-Asian origin had the lowest BP and BMI. There were also a high proportion of individuals of Arab origin who were diabetic and on antihypertensive medications. Obesity (especially abdominal obesity) is also a major concern among individuals from the Indian subcontinent and is an important cardiovascular risk factor [19]. This was evident in our cohort as well. Unfortunately, waist and hip measurements, which would have given us more understanding of the patterns of obesity and the ethnic differences in body fat patterns, were not included as part of the study. The South Asians had similar blood pressures and BMI as those of Arab ethnicity indicating both these groups have high cardiovascular risk. Of note, those of Caucasian ethnicity were older than the other groups and had a higher proportion of individuals who were already on antihypertensive medications (33.2%) but only a small proportion of them had blood pressure in the hypertensive range (0.6%). The other groups had lower number of people on antihypertensive medications but higher proportion of people with BP in the hypertensive range. Whilst we are unable to explain this ethnic disparity in BP and BP control with the information collected, this could reflect the different employment and educational status of the different ethnic groups in the Arabian Gulf countries [20].

There was a wide discrepancy in the number of individuals screened over the 3 years. Setting up a screening programme of this magnitude requires a considerable amount of planning and training of the volunteers. In 2017 when the programme was first run, there were many logistic hurdles and not sufficient time to prepare and hence only a small number of individuals were screened. In 2018, lessons were learnt from the experience in 2017 and there was sufficient time to train the volunteers and the screening sites were able to better prepare and prevent the logistic problems that had occurred the previous year. Also in 2018, there were many promotional events and increased number of advertisements on social media for the programme. There were also many more screening sites set up. However in 2019, as the Holy month of Ramadan had covered most of the month of May, recruitment of individuals was difficult and the numbers screened had fallen again.

The American Heart Association introduced the concept of ideal cardiovascular health in 2010, which gives an overview of both primary prevention and secondary prevention in the community [21]. It consists of 7 components (Smoking, physical activity, BP control, blood sugar control, healthy diet, blood cholesterol and BMI) that strongly corelate with cardiovascular risk factors. Prevention, predictive and personalised heath is the key for BP control and thereby the cardiovascular health of the community at large [22, 23]. Mass media campaigns and initiatives such as the MMM programme helps to improve awareness regarding the importance of monitoring and controlling BP [24, 25]. Besides improving awareness, data from such programmes provide the baseline information for policy makers to design and implement strategies for cardiovascular health promotion and cardiovascular disease prevention [23].

It is however, too early to assess whether the MMM programme had an effect on the overall BP control in Oman. Despite the considerable amount of publicity, only a few individuals mentioned that they had participated in more than one MMM programme. In addition, no personal identifying information was collected, hence it was not possible to link the BP of an individual who had participated in more than one MMM programme to their previous readings. In addition, 3 years is perhaps too short a time interval to assess whether the MMM campaign made a difference in overall BP control as there was no difference in the average blood pressure between the 3 years.

There are a few limitations to our survey. Firstly, most of our screening centres were located at various sites in different hospitals. Therefore, the screening was usually on healthy adults who came to visit relatives or were patients' attendants. Our screened population also included healthcare staff and staff at other workplaces of our volunteers. Our subjects are therefore relatively young and healthy with only a small proportion being diabetic or having ischaemic heart disease or a previous stroke. Another limitation of the study was incomplete data in some patients which therefore precluded them from being used in the final analysis. Patients with only one BP reading were not included in the final BP analysis as the first readings were significantly higher than the average of the second and third reading. This has implications for other screening programmes, where it is imperative to have three BP readings to get the correct diagnosis of hypertension.

Other data such as socioeconomic status, employment status, and educational status were not collected and this might have given us more information on the effect of these factors on BP control, lifestyle, comorbidities etc. As Oman has a huge migrant working population with varied types of jobs, these factors play an important role in health awareness, access to health care and overall health of the individuals. Family history and genetic information were not collected but would have also helped us gain more insight into the patterns of familial hypertension in Oman as demonstrated in other populations [26].

The history of cardiovascular risk factors was self-reported and we were unable to verify them due to the scale of the screening programme. It is possible that some patients may have misreported this. Similarly, the anthropometric data were self reported when the patient stated that they had checked them recently. Although there were instances where it was checked again at the patient request, there could have been some error in self reporting.

Another potential limitation is a selection bias. We did not go house to house to measure BP, but instead, measured the BP of those who approached the BP monitoring stations that were set up at the various sites. It is possible that we inadvertently included mainly individuals who are interested in their health and therefore potentially had better BP control than those who did not volunteer to have their BP checked.

The survey was conducted almost extensively in the urban areas of Muscat and therefore does not accurately represent the true prevalence of hypertension in Oman, although this does give us an idea of its prevalence and good data on control rates among those treated. This will help to encourage more BP screening events and help to educate the general public regarding the dangers of hypertension and remind physicians regarding the need for adequate BP control among hypertensive patients and those with preexisting cardiovascular disease.

CONCLUSIONS
The MMM screening programme has helped identify individuals with high BP with many of them diagnosed to have hypertension for the first time. It also helped identify a high proportion of high-risk patients having high BP and individuals with high BMI. Conducting such mass screening programmes on a regular basis would help us identify more previously undiagnosed hypertensive patients and would have a positive impact on public health. Screening programmes should also target the "high risk" groups and the high-risk ethnic groups especially those in the lower socio-economic category who might have limited access to health care.

SUMMARY

What is known about this topic

- Hypertension is widely prevalent all over the world and the incidence appears to be increasing in some countries.
- Hypertension is often asymptomatic and hence it is imperative for community screening programmes.
- Hypertension is often clustered with other cardiovascular risk factors.

What this study adds

- The prevalence of hypertension in Oman is around 30% in our study population which is in keeping with previous studies.
- A high proportion of patients on antihypertensive medication have blood pressure in the hypertensive range.
- Blood pressure rises with other cardiovascular risk factors such as diabetes, age, body mass index.
- There are ethnic differences in blood pressure readings in Oman.

REFERENCES
1. Forouzanfar MH, Liu P, Roth GA, Ng M, Biryukov S, Marczak L, et al. Global burden of hypertension and systolic blood pressure of at least 110 to 115 mmHg, 1990–2015. JAMA. 2017;317:165–82.
2. GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392:1923–94.
3. Hypertension the silent killer. 2019. https://www.who.int/cardiovascular_diseases/publications/global_brief_hypertension/en/. Accessed 26 Jun 2021.
4. Nadar S, Lip GY. Secular trends in cardiovascular disease. J Hum Hypertens. 2002;16:663–6.
5. Beaney T, Schutte AE, Tomaszewski M, Ariti C, Burrell LM, Castillo RR, et al. May Measurement Month 2017: an analysis of blood pressure screening results worldwide. Lancet Glob Health. 2018;6:e736–e743.
6. Beaney T, Burrell LM, Castillo RR, Charchar FJ, Cro S, Damasceno A, et al. May Measurement Month 2018: a pragmatic global screening campaign to raise

awareness of blood pressure by the International Society of Hypertension. Eur Heart J. 2019;40:2006–17.

7. Beaney T, Schutte AE, Stergiou GS, Borghi C, Burger D, Charchar F, et al. May Measurement Month 2019: The Global Blood Pressure Screening Campaign of the International Society of Hypertension. Hypertension. 2020;76:333–41.

8. Oman fact file. 2019. https://www.cia.gov/library/publications/the-world-factbook/geos/mu.html. Accessed 26 Jun 2021.

9. Population in Oman. 2019. https://data.gov.om/OMPOP2016/population?indicator=1000140&region=1000020-muscat&nationality=1000010-omani. Accessed 26 Jun 2021.

10. Non communicable diseases in Oman. 2019. https://www.who.int/nmh/countries/omn_en.pdf?ua=1. Accessed 26 Jun 2021.

11. Al-Lawati J, Sulaiman K, Panduranga P. The epidemiology of acute coronary syndrome in Oman: results from the Oman-RACE study. Sultan Qaboos Univ Med J. 2013;13:43–50.

12. Hasab AA, Jaffer A, Hallaj Z. Blood pressure patterns among the Omani population. East Mediterr Health J. 1999;5:46–54.

13. Melgarejo JD, Maestre GE, Thijs L, Asayama K, Boggia J, Casiglia E, et al. Prevalence, treatment, and control rates of conventional and ambulatory hypertension across 10 populations in 3 continents. Hypertension. 2017;70:50–8.

14. NCD Risk Factor Collaboration (NCD-RisC). Long-term and recent trends in hypertension awareness, treatment, and control in 12 high-income countries: an analysis of 123 nationally representative surveys. Lancet. 2019;394:639–51.

15. Williams B, Mancia G, Spiering W, Agabiti RE, Azizi M, Burnier M, et al. ESC/ESH Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension. J Hypertens. 2018;36:1953–2041.

16. ALNohair S. Obesity in gulf countries. Int J Health Sci. 2014;8:79–83.

17. Tax on sugary drinks in Oman. 2020. https://muscatdaily.com/Oman/388197/Tax-on-sugary-drinks-starts-today. Accessed 26 Jun 2021.

18. al-Shammari SA, Khoja TA, al-Maatouq MA, al-Nuaim LA. High prevalence of clinical obesity among Saudi females: a prospective, cross-sectional study in the Riyadh region. J Trop Med Hyg. 1994;97:183–8.

19. Prasad DS, Kabir Z, Dash AK, Das BC. Abdominal obesity, an independent cardiovascular risk factor in Indian subcontinent: a clinico epidemiological evidence summary. J Cardiovasc Dis Res. 2011;2:199–205.

20. Malecki EJ, Ewers MC. Labor migration to world cities: with a research agenda for the Arab Gulf. Prog Hum Geogr. 2007;31:467–84.

21. Lloyd-Jones DM, Hong Y, Labarthe D, Mozaffarian D, Appel LJ, Van HL, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. Circulation. 2010;121:586–613.

22. Lloyd-Jones DM, Evans JC, Larson MG, Levy D. Treatment and control of hypertension in the community: a prospective analysis. Hypertension. 2002;40:640–6.

23. Wang W. Cardiovascular health in China: low level vs high diversity. Lancet Reg Health West Pac. 2020.

24. Oto MA, Ergene O, Tokgozoglu L, Ongen Z, Kozan O, Sahin M, et al. Impact of a mass media campaign to increase public awareness of hypertension. Turk Kardiyol Dern Ars. 2011;39:355–64.

25. Tabassum R, Froeschl G, Cruz JP, Colet PC, Dey S, Islam SMS. Untapped aspects of mass media campaigns for changing health behaviour towards non-communicable diseases in Bangladesh. Glob Health. 2018;14:7.

26. Wang W, Wise C, Baric T, Black ML, Bittles AH. The origins and genetic structure of three co-resident Chinese Muslim populations: the Salar, Bo'an and Dongxiang. Hum Genet. 2003;113:244–52.

AUTHOR CONTRIBUTIONS
Data collection: Hal-Riyami, IA, SA, AA, H-Allawati, H. Al-Hadi, BP, SM, MM, Data analysis: TB, NRP, SKN. Manuscript writing: H-Al-Riyami, SKN, TB.

COMPETING INTERESTS
The authors declare no competing interests.

ADDITIONAL INFORMATION
Correspondence and requests for materials should be addressed to Sunil K. Nadar.

Reprints and permission information is available at http://www.nature.com/reprints

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.