



Awareness of Dietary Approaches to Stop Hypertension Diet, its Effect, Impact, Adherence and Use of trackers on Hypertension Management in Asian Adults: A Three- Cohort Observational Study

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Abstract

Objective: A healthy and balanced diet provides the body with all the essential vitamins, minerals, micro and macro nutrients for energy, growth and repair along with reducing the risk of many chronic diseases like hypertension, diabetes and cancers. This study evaluates the role of Dietary Approaches to Stop Hypertension in controlling and management of hypertension. Three different cohorts (hypertensive patients, physicians and dietitians treating hypertensive patients) were surveyed for this study in order to understand the effect and feasibility of DASH diet in controlling and managing hypertension.

Methods: Three different cohorts of varied sample size were evaluated in the study. The sample size included 416 Patients diagnosed with hypertension, 48 Physicians treating hypertensive patients and 50 dietitians who gave dietetic consultation to hypertensive patients. Different questionnaires were circulated to each individual cohort and their responses was captured either in paper/digital format.

Results: The awareness of DASH diet among the three cohorts was varied, only 58.41% of the patients were aware of the DASH diet in varying degrees (superficial or very well), when compared to 77% of the physicians and 98% of the dietitians indicating that awareness of the diet was lesser among the general patient population when compared to the dietitian and physicians.

Patients who followed DASH diet saw reduction in both their systolic and diastolic readings. 54.17% patients found 3-7mmHg reduction in systolic BP and 79.17% patients found 1-3mmHg reduction in diastolic BP. The longer they adhered to DASH diet, higher was their likelihood of experiencing substantial BP reductions.

Physicians too observed reduction in both systolic and diastolic BP readings in their patients who followed DASH diet. Within the five independent approaches of DASH diet, physicians saw reduction in BP reading for their patients who “reduced their salt intake”, “reduced saturated fatty foods and red meat”, or “increased intake of potassium rich food”. The Physicians however did not significantly see reduction in BP readings in their patients who “reduced sugar intake”, or “increased fruits, vegetables, nuts and whole grains”.

Similar findings were seen by dietitians as well. They observed reduction in both systolic and diastolic BP reading in their patients who followed DASH diet.

Within the five independent approaches of DASH diet, dietitians saw reduction in BP reading for their patients who “increased fruits, vegetables, nuts and whole grains”, or “increased intake of potassium rich food”. Dietitians did not significantly see reduction in BP readings in their patients who “reduced their salt intake”, “reduced sugar intake”, or “reduced saturated fatty foods and red meat”.

A significant proportion of patients who followed DASH diet, felt confident about sustaining the diet over a long period of time and a majority of them did not face any challenges in following the diet. According to the physicians and dietitians there was no significant difference in the challenges that the patients faced in sustaining the diet. The patients who visited the dietitians found it easy to follow the diet.

While a significant proportion of patients and physicians felt use of trackers/smart apps sometimes helped in managing and adhering to diet, physicians felt these trackers often helped in adhering and managing to the diet.

Conclusion: *The study clearly found that there was reduction in both systolic and diastolic BP readings in patients who followed DASH diet. This finding was consistent in all the three surveyed cohorts. In terms of awareness of the diet, the study clearly highlighted the lack of awareness among the general patient population in India regarding DASH dietary intervention method. This shows the need for implementing awareness campaigns as a public health initiative, having frequent health check campaigns, use of social media to create awareness among the general population and implementing government health initiatives.*

Keywords: *high blood pressure, DASH diet, patient, physician, dietitians, systolic, diastolic, tracker, adherence.*

Introduction

Hypertension, which is also known as high blood pressure is a medical condition that occurs when the force of blood flow through the blood vessels is persistently elevated. Every time the heart beats, blood is pumped into the blood vessels or arteries. Blood pressure is the force created when the blood pushes against the wall of arteries during the pumping of the heart. Higher the pressure the harder the heart has to pump thereby putting strain on the heart over long run. Hypertension is a complex medical condition with varied underlying causes like physical inactivity, lifestyle factors, diet rich in salt, genetic factors, family history etc [1].

Blood pressure is often denoted as two numbers and is commonly expressed as the ratio of systolic BP and diastolic BP. The systolic blood pressure (SBP), denotes the pressure exerted in the blood vessels when the heart contracts and the diastolic blood pressure (DBP), denotes the pressure exerted on the blood vessels when the heart relaxes. Blood pressure can be quite variable, even in the same person and can go up and down with normal daily activities like exercise, eating salty food etc. Hypertension is diagnosed when a patient's BP is recorded at or above 130mmHg with two or more readings taken on two or more occasions. As per WHO (World Health Organisation) guidelines, individuals having systolic blood pressure ≥ 140 mmHg or diastolic blood pressure of ≥ 90 mmHg are considered to be hypertensive and require pharmacological intervention. Hypertension is a common and serious medical condition, and is the leading comorbidity factor for deaths globally [2].

Uncontrolled and prolonged hypertension is known to have an adverse impact on various vital organs. Hence a timely intervention, treatment and management of hypertension is crucial and important. Lifestyle intervention acts as a first line management strategy for the treatment and control of hypertension. This includes dietary adjustments like DASH diet, low intake of sodium, minimum 30min of physical activity daily, weight reduction, moderate consumption of alcohol, reduction of sodium and stress management [3].

The Dietary Approaches to Stop Hypertension (DASH) diet is a flexible and balanced eating plan that creates a heart healthy eating style for life. It was named the "Best Heart Healthy Diet" and "Best diet for High blood pressure" by US News and World Report in 2025 [4,5]. DASH diet is a scientifically developed nutritional regimen developed in 1990s by the National Heart, Lung and Blood Institute (NHLBI) for the American population to support hypertension prevention and control. This diet recommends increased intake of fresh fruits and vegetables, low intake of fat and dairy products, increased intake of whole grains, poultry, fish and nuts while limiting the intake of salt, saturated fatty acids, red meat, sweets and sugar containing beverages [5,6].

Since the formulation of this diet pattern, DASH diet has been extensively studied over the years. Many clinical trials have been formulated and conducted over the years to study its significance and effectiveness in managing hypertension. The initial DASH study which was sponsored by NHLBI showed reduction in BP

readings in individuals who followed DASH diet when compared to those who followed the American diet [7,8,9]. The PREMIER trial investigated the effect of lifestyle interventions including the DASH diet on blood pressure reduction. Findings of this study showed a decrease in systolic blood pressure of [11].1mmHg in the DASH diet group [10]. The OMNIHEART TRIAL (Optimal Macronutrient Intake Trial to Prevent Heart Disease) aimed to evaluate the effect of three different diets, including a variation of DASH diet on blood pressure. Results of this trial showed a greater reduction in BP readings in patients who were on modified DASH diet than DASH diet alone [10,11]. Furthermore, a study published in the American Heart Association Journal in 2001 investigated the efficacy of the DASH diet in treating Stage 1 Isolated Systolic Hypertension (ISH). Individuals in the DASH diet group experienced a significant decrease in systolic blood pressure by 11.8 ± 9.3 mmHg and a notable reduction in diastolic blood pressure while urinary sodium levels remained consistent [10].

Since DASH diet was mainly developed by the NHLBI for the US population awareness of this diet among Asian countries is generally low. Awareness about the disease and its associated morbidity has an important role in managing and controlling hypertension among the general population. Various studies in the past have shown that the awareness level among the rural and urban Indian population was varied and low and that this diet needs to be promoted as routine in patient care by healthcare personnel to increase its awareness.[12,13]. Since DASH diet is a lifestyle modification diet, adhering to this diet is always challenging. Adherence to the diet can be influenced by various social and economic factors and understanding the barriers for following this diet is crucial for improving adherence. Prior studies identified several potential barriers in adhering to diet like high cost of healthy food, lack of available or accessible healthy food, over accessibility and low cost of unhealthy food, cultural influence on food preference and diet norms [25. 28].

Materials and Methods

The current study was survey-based observational research conducted in three different cohort groups namely hypertensive Patients, Physicians and Dietitians. For all three groups the target population was chosen from various geographical locations across India (Pan India). All the participants selected for the study were >18yrs of age. All the 416 patients recruited for the study were diagnosed with hypertension and were of Asian origin. All the 48 physicians and 50 dietitians who had a good influx of Asian origin hypertensive patients were only recruited for the study. Separate questionnaires were circulated for each cohort and their responses were captured either in paper/digital format. Ethics committee approval was sought before enrolling the participants into the study (EC No.HCH-EC_05/20230722).

Results

Awareness of DASH diet among the three cohorts were analysed.

Among the 416 patients who were enrolled in the study, 243 (58.41%) were aware of DASH diet of which, 28.85% had a superficial idea and 29.56% knew about it very well (Table 1, Fig 1).

Awareness of DASH Diet	No. of patients
No awareness	173 (41.59%)
Have superficial idea	120 (28.85%)
Know very well	123 (29.56%)
Total	416

Table 1: Awareness of DASH in patients



Fig 1: Awareness of DASH in patients

Among the 48 physicians, 37 (77.08%) were aware of DASH diet and 11 (22.92%) were unaware indicating a small percentage of physicians are still unaware.

Awareness of DASH Diet	No. of physicians
No	11 (22.92%)
Yes	37 (77.08%)
Total	48

Table 2: Awareness of DASH among physicians

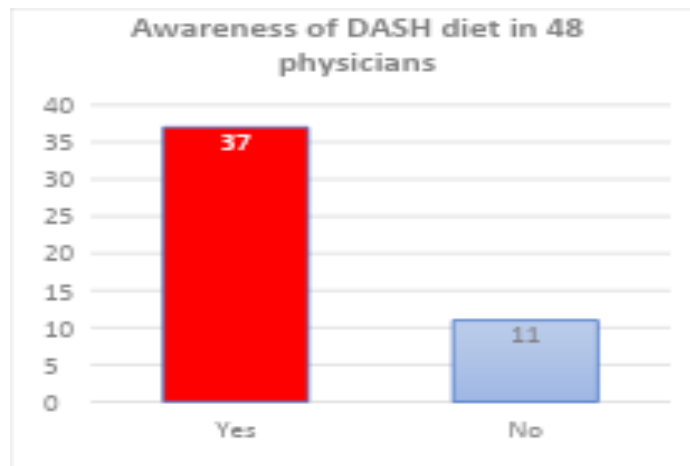


Fig 2: Awareness of DASH among physicians

Among the 50 dietitians enrolled in the study, 49 (98%) were aware of the DASH diet and only 1 was unaware of the diet.

Awareness of DASH Diet	No. of dietitians
No	1 (2%)
Yes	49 (98%)
Total	50

Table 3: Awareness of DASH among dietitians



Fig 3: Awareness of DASH among dietitians

In order to determine if there is any correlation between awareness of DASH diet and the cohort Chi-Square Test for Independence was employed ($\chi^2 = 34.291$; p-value= 3.58×10^{-8}). Since the p value is <0.05 we can say that there is statistically significant association between the awareness of DASH diet and the cohort. Cramér's V test for finding the strength of the correlation coefficient between the two variables was also used (Cramer's $V = 0.258$) which confirms that awareness of DASH diet is moderately dependent on whether the subject is a patient, physician or dietician. From the above tables it is clear that Dieticians were strongly aware of the DASH diet, while Patients tend to be unaware of the diet.

The physicians and dieticians were also asked about the prevalence of awareness of DASH diet in patients visiting them.

Patient awareness of DASH diet	# of physicians
Often	6 (12.5%)
Sometimes	18 (37.5%)
Never	24 (50%)
Total	48

Table 4: Awareness of DASH in patients visiting physicians

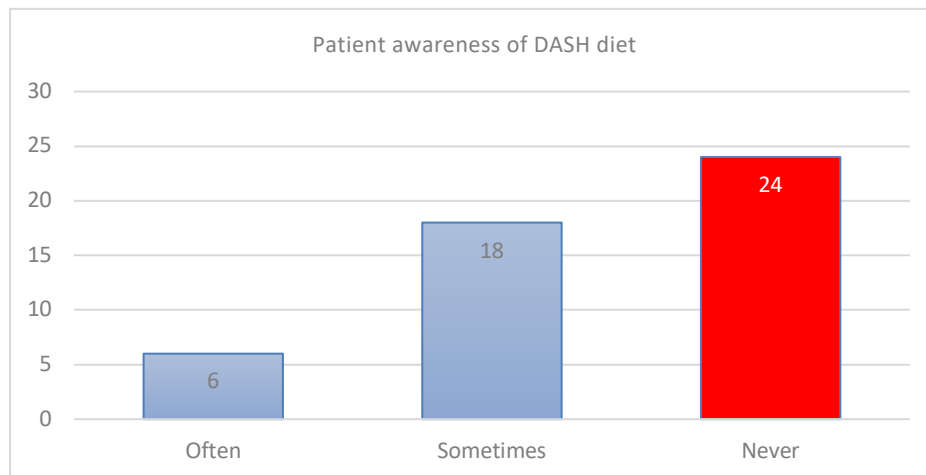


Fig 4: Awareness of DASH in patients visiting physicians

Patient awareness of DASH diet	# of dietitians
Never	17 (34%)
Sometimes	21 (42%)
Often	12 (24%)
Total	50

Table 5: Awareness of DASH among patients visiting dietitian



Fig 5: Awareness of DASH among patients visiting dietitian

We employed the Chi-Square Test for Independence for determining if there is any correlation between the prevalence of awareness of the diet, and the cohorts of patients visiting physician and dietitians ($\chi^2 = 3.386$, $p = 0.184$). The p value > 0.05 indicates there is no difference between the prevalence of awareness of DASH diet within patients, and whether these patients consulted the physicians or the dietitians.

The effect of DASH diet on BP reduction was also studied among the three cohorts.

Out of the 416 hypertensive patients recruited in the study, only 243 knew about DASH diet among whom only 171 (70.37%) followed the diet for varied duration of time from 6 months to more than a year. Out of these 171 patients, 144 (84.21%) found changes in their BP readings since the time they started following the diet in comparison to the 27 (15.79%) who didn't see any change in BP reading. To determine whether there is a correlation between following the DASH diet and reduction in BP readings, Chi Square test of independence was employed. There was statistically significant association between following DASH diet and seeing a reduction in BP readings ($\chi^2 = 124.29$, $p < 0.05$). We also employed Cramer's V test for finding the

strength of correlation coefficient between the two variables. Cramer's $V=0.715$ suggested there was a very strong correlation between the two variables (following DASH and reduction in BP).

Following DASH diet→ Reduction in BP readings ↓	Yes	No	Total
Yes	144	5	149
No	27	67	94
Total	171	72	243

Table 6: Association between DASH diet and BP readings

Table 7 and 8 shows the approximate change in systolic and diastolic BP readings found in these 144 patients.

Change in SBP		
Range	No. of patients	percentage
1-3mmHg	27	18.75%
3-7mmHg	78	54.17%
7-10mmHg	38	26.39%
>10mmHg	1	0.69%
Total	144	100%

Table 7: Change in systolic blood pressure

Change in DBP		
Range	No. of patients	percentage
1-3mmHg	114	79.17%
3-5mmHg	29	20.14%
>5mmHg	1	0.69%
Total	144	100%

Table 8: Change in diastolic blood pressure

The above tables clearly shows that there was around 3-7mmHg reduction in SBP and 1-3mmHg reduction in DBP in majority of the patients. The longer the patients adhered to DASH diet, higher was the likelihood of experiencing substantial BP reductions. Below are the tables and graphs showing a reduction in Systolic and Diastolic BP readings v/s the duration of following the DASH diet.

Reduction in Systolic BP →	No change	1-3mm /Hg	3-7mm /Hg	>7mm /Hg	Total
Duration of DASH diet followed by patients ↓					
Just started	22	10	7	1	40
since-past-6-months	5	14	45	11	75
since-last-1-year	0	3	15	14	32
more-than-a-year	0	0	11	13	24
Total	27	27	78	39	171

Table 9: Patients seeing reduction in systolic BP readings based on duration of diet

Note: The categories “7-10mm/Hg” and “>10mm/Hg” have been clubbed together as “>7mm/Hg” to get statistically significant number of observations.

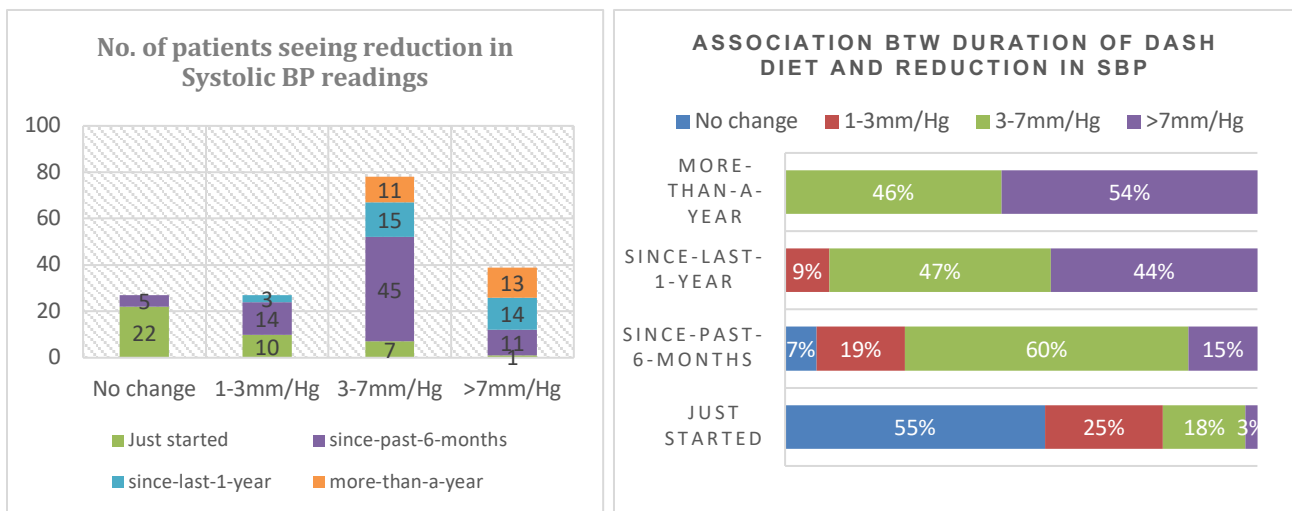


Fig 6: Patients seeing reduction in systolic BP readings

In order to determine whether there was a correlation between the duration of following DASH diet and the reduction in BP readings, Chi square test for independence was employed. A significant association between the duration of following DASH diet and the reduction in systolic BP readings was observed ($\chi^2 = 95.17$, $p < 0.05$). Cramer's V test was used to find the strength of correlation co-efficient between the two variables. A strong association between the duration of following DASH diet and reduction in systolic BP readings was found (Cramer's V test=0.431). We further used Spearman's rank coefficient in addition to Cramer's V test to validate the strength of correlation. ($r_s = 0.6195$) indicated a strong positive correlation between the two variables. Post-hoc analysis was done to further validate the findings (Table 10).

Reduction in Systolic BP → Duration of DASH diet followed by patients ↓	No change	1-3mm /Hg	3-7mm /Hg	>7mm /Hg
Just started	6.241	1.466	-2.633	-2.689
since-past-6-months	-1.988	0.627	1.845	-1.476
since-last-1-year	-2.248	-0.913	0.106	2.481
more-than-a-year	-1.947	-1.947	0.016	3.217

Note: Significant positive values ($> +1.96$) are in yellow.

Table 10: Post hoc analysis to establish association between DASH diet and systolic BP readings

Similar to SBP, statistically significant association between the duration of DASH diet and reduction in diastolic BP readings was seen ($\chi^2 = 110.319$, $P < 0.05$). We employed the Cramér's V test for finding the strength of the correlation coefficient between the two variables. A strong correlation between the duration of following the DASH diet and the reduction in diastolic BP was found (Cramér's V = 0.468). Spearman's rank coefficient was used to further validate the strength of association. $r_s = 0.7568$ indicates a strong positive correlation between the two variables. Post hoc analysis was done to further re-establish our findings. The heat map for the standard residuals calculated is shown in table 12.

Reduction in Diastolic BP →	No change	1-3mm /Hg	>3mm /Hg	Total
Duration of DASH diet followed by patients ↓				
Just started	22	18	0	40
since-past-6-months	5	65	5	75
since-last-1-year	0	23	9	32
more-than-a-year	0	8	16	24
Total	27	114	30	171

Table 11: Patients seeing reduction in diastolic BP readings

Note: The categories “3-5mm/Hg” and “>5mm/Hg” have been clubbed together as “>3mm/Hg” to get statistically significant number of observations

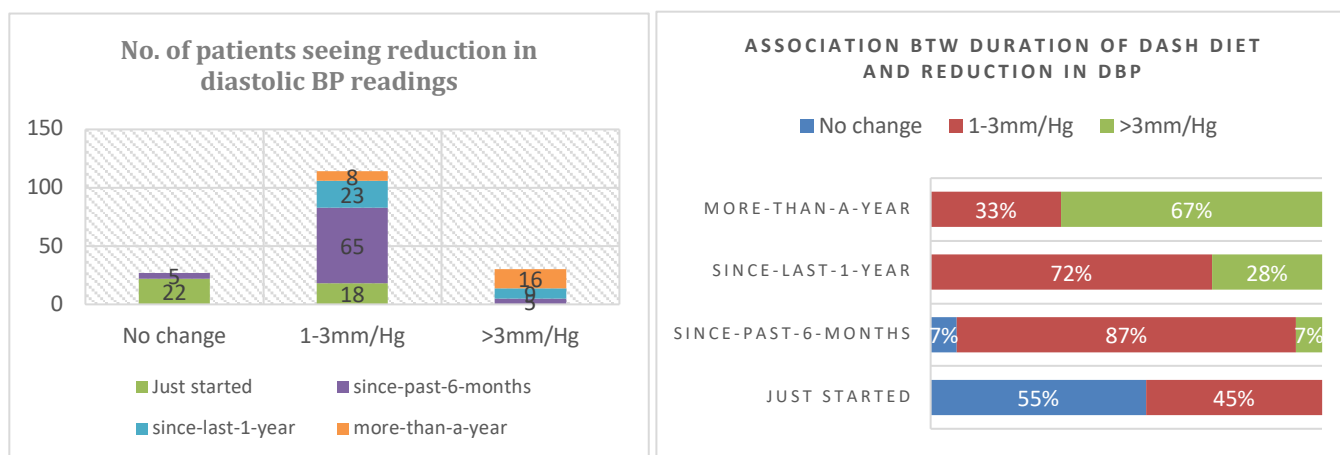


Fig 7: Patients seeing reduction in diastolic BP readings

Reduction in Diastolic BP →	No change	1-3mm /Hg	>3mm /Hg
Duration of DASH diet followed by patients ↓			
Just started	6.241	-1.678	-2.649
since-past-6-months	-1.988	2.121	-2.249
since-last-1-year	-2.248	0.361	1.429
more-than-a-year	-1.947	-2.000	5.745

Note: Significant positive values (> +1.96) are in yellow.

Table 12: Post hoc analysis to establish association between DASH diet and diastolic BP readings

With respect to the physicians, 33 (68.75%) found a reduction in BP readings in their patients who followed DASH diet whereas 15 (31.25%) did not see any reduction. Within those 33 physicians, 21 (43.75%) saw a slight reduction, while 12 (25.00%) saw a significant reduction in their patients’ BP readings.

Reduction in the BP readings after following DASH diet		
Degree	Physicians	Percentage
No change	15	31.25%
Slight change	21	43.75%
Significant change	12	25.00%

Table 13: Change in BP readings after DASH diet

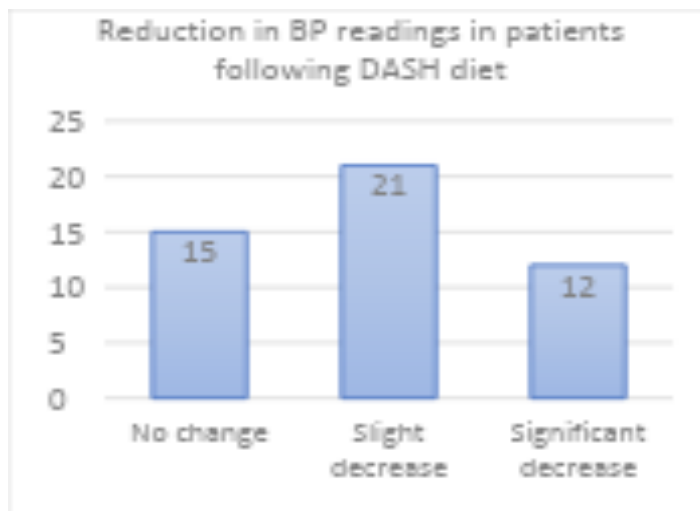


Fig 8: Change in BP after DASH diet

The physicians also stated that they saw reduction in their patients’ BP readings when each of the five approaches within DASH diet were followed independently. Chi-Square Goodness of Fit Test (on each of the 6 scenarios independently) was employed to test which of the scenarios was successful in the reduction of BP readings. The observation table looked as below:

Reduction observed in BP readings by:	Yes	No	Total
following DASH diet	33 (68.75%)	15 (31.25%)	48
reducing sugar intake	23 (47.91%)	25 (52.08%)	48
increasing fruits, vegetables, nuts and whole grain	30 (62.50%)	18 (37.50%)	48
reducing salt intake	36 (75%)	12 (25%)	48
reducing saturated fatty foods and red meat	44 (91.66%)	4 (8.33%)	48
increasing intake of potassium rich food	44 (91.66%)	4 (8.33%)	48

Table 14: Reduction in BP readings

Note: "Following DASH diet" means the application all 5 approaches together, while the individual five approaches of DASH diet are taken as independent to each other for the purpose of this study. Significance is at 95% confidence level ($p < 0.05$)

The extent of reduction observed by the physicians in systolic and diastolic BP readings of the patients who followed each approach of DASH diet independently is highlighted in table 15 and 16 respectively. Moderate reduction in systolic BP (3-7mmHg) was observed in patients who "reduced their sugar intake", "increased fruits, vegetables, nuts, whole grains", or "reduced salt intake"; while higher reduction (7-10mmHg) was observed in patients who "reduced saturated fatty foods and red meat".

Reduction observed in Systolic BP readings → Approaches within DASH diet ↓	1-3mm /Hg	3-7mm /Hg	7-10mm /Hg	>10mm /Hg	Total
following DASH diet	8	12	9	4	33
reducing sugar intake	3	18	2	0	23
increasing fruits, vegetables, nuts, whole grain	8	15	5	2	30
reducing salt intake	5	18	13	0	36
reducing saturated fatty foods and red meat	9	14	19	2	44
increasing intake of potassium rich food	10	12	17	5	44

Table 15: Reduction found by physicians in systolic BP readings

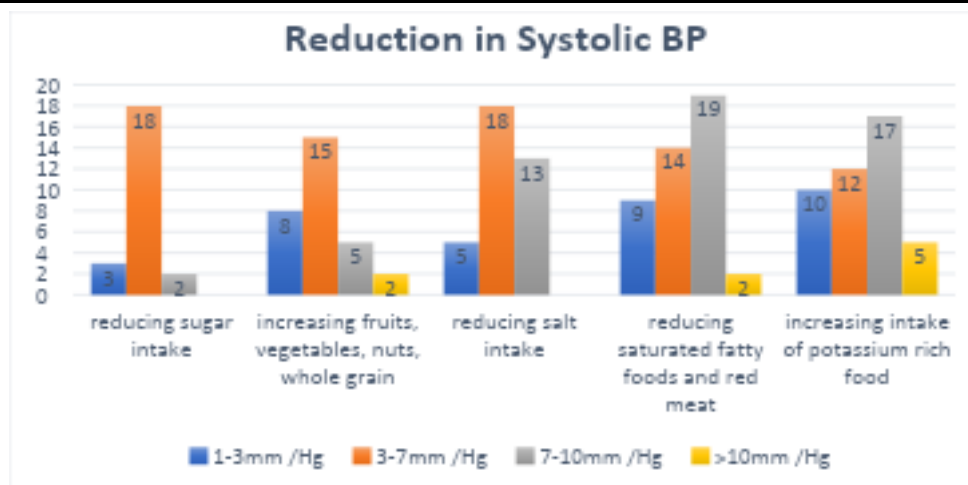


Fig 9: Reduction found by physicians in systolic BP readings

The heat map for the standard residuals calculated for each approach independently is shown below:

Reduction observed in systolic BP readings → Approaches within DASH diet ↓	1-3mm /Hg	3-7mm /Hg	7-10mm /Hg	>10mm /Hg
following DASH diet	-0.09	1.31	0.26	-1.48
reducing sugar intake	-1.15	5.11	-1.56	-2.40
increasing fruits, vegetables, nuts, whole grain	0.18	2.74	-0.91	-2.01
reducing salt intake	-1.33	3.00	1.33	-3.00
reducing saturated fatty foods and red meat	-0.60	0.90	2.41	-2.71
increasing intake of potassium rich food	-0.30	0.30	1.81	-1.81

Fig 10: Post hoc analysis of systolic BP readings

Note: Significant positive values (> +1.96) are in yellow.

With respect to diastolic BP, slight reduction (1-3mmHg) was observed in patients who “reduced their sugar intake”, “increased fruits, vegetables, nuts, whole grains”, “reduced salt intake”, or “reduced saturated fatty foods and red meat”.

Reduction observed in Diastolic BP readings → Approaches within DASH diet ↓	1-3mm /Hg	3-5mm /Hg	>5mm /Hg	Total
following DASH diet	16	10	7	33
reducing sugar intake	15	7	1	23
increasing fruits, vegetables, nuts and whole grain	18	8	4	30
reducing salt intake	20	13	3	36
reducing saturated fatty foods and red meat	25	11	8	44
increasing intake of potassium rich food	18	15	11	44

Table 16: Reduction in diastolic BP

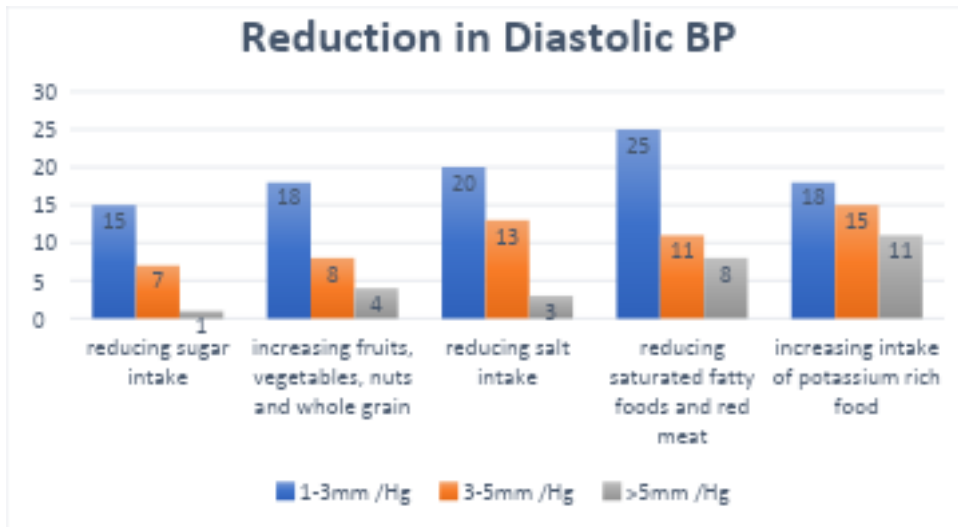


Fig 11: Reduction found in diastolic BP by physicians

The heat map for the standard residuals calculated for each approach independently is shown below:

Reduction observed in diastolic BP readings → Approaches within DASH diet ↓	1-3mm /Hg	3-5mm /Hg	>5mm /Hg
following DASH diet	1.51	-0.30	-1.21
reducing sugar intake	2.65	-0.24	-2.41
increasing fruits, vegetables, nuts, whole grain	2.53	-0.63	-1.90
reducing salt intake	2.31	0.29	-2.60
reducing saturated fatty foods and red meat	2.70	-0.96	-1.74
increasing intake of potassium rich food	0.87	0.09	-0.96

Table 17: Post hoc analysis of reduction in diastolic BP

Note: Significant positive values (> +1.96) are in yellow.

Table 18 summarizes the reduction in BP readings observed by the physicians in their patients who followed DASH diet in general and in those who adhered to each of the five approaches to DASH diet independently.

Reduction observed in BP readings → Approaches within DASH diet ↓	Significant no. of patients see reduction	Most occurring Systolic BP reduction				Most occurring Diastolic BP reduction		
		1-3mm /Hg	3-7mm /Hg	7-10mm /Hg	>10mm /Hg	1-3mm /Hg	3-5mm /Hg	>5mm /Hg
Following DASH Diet	✓							
reducing sugar intake			✓			✓		
increasing fruits, vegetables, nuts and whole grain			✓			✓		
reducing salt intake	✓		✓			✓		
reducing saturated fatty foods and red meat	✓			✓		✓		
increasing intake of potassium rich food	✓			✓ *				

Table 18: Summary of reduction in BP found by physicians in their patients who followed DASH diet

Similar assessment was also done in the dietitian cohort. Out of the 50 dietitians, 47 (95.92%) said they saw reduction in BP readings in their patients who followed DASH diet in general. Similar reduction was seen when each of the independent approaches of DASH diet was employed (table 17). Chi-Square Goodness of Fit Test was applied (on each of the 6 scenarios independently) to test which of the scenarios is successful in reduction of BP readings.

Reduction observed in BP readings by:	Yes	No	Total
following DASH diet	47 (95.92%)	2 (4.08%)	49
reducing sugar intake	20 (40.82%)	29 (59.18%)	49
increasing fruits, vegetables, nuts and whole grain	47 (95.92%)	2 (4.08%)	49
reducing salt intake	28 (57.14%)	21 (42.86%)	49
reducing saturated fatty foods and red meat	25 (51.02%)	24 (49.98%)	49
increasing intake of potassium rich food	44 (89.80%)	5 (10.20%)	49

Note: “Following DASH diet” means the application all 5 approaches together, while the individual five approaches of DASH diet are taken as independent to each other for the purpose of this study. Significance is at 95% confidence level ($p < 0.05$)

Table 19: Reduction in BP readings observed by dietitians in their patients

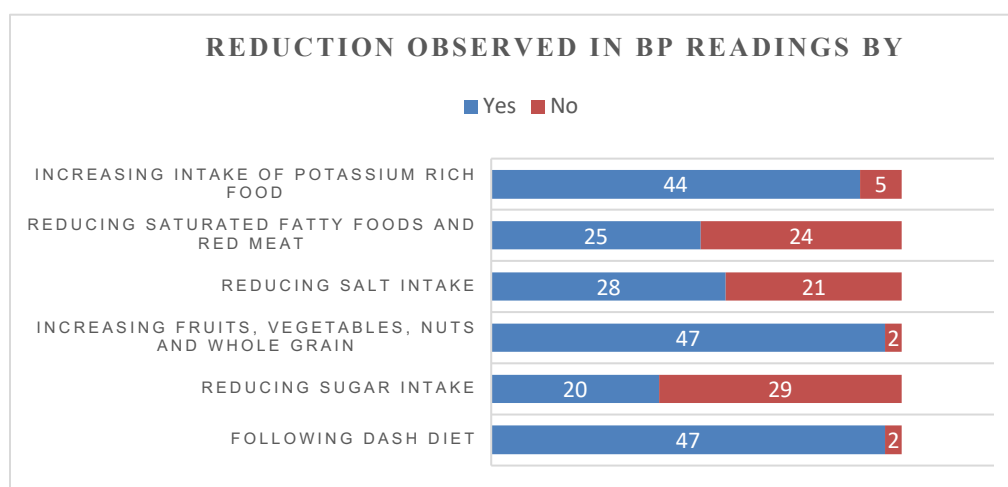


Fig 12: Reduction in BP readings observed by dietitians in their patients

A significant reduction in BP readings in patients who followed DASH diet as a whole ($\chi^2=41.327, p=1.29 \times 10^{-10}$) and in patients who increased fruits, vegetables, nuts and whole grains ($\chi^2=41.327, p=1.29 \times 10^{-10}$) and increased potassium rich food ($\chi^2=31.041, p=2.53 \times 10^{-8}$) was observed. Moderate reduction (3-7mm/Hg) in SBP was seen when DASH diet was followed in general as well as when independent approaches of “reduced sugar intake”, “increased fruits, vegetables, nuts, whole grains”, “reduced saturated fatty foods and red meat” or “increased intake of potassium rich food” was followed; while they observed slight reduction (1-3mm /Hg) in patients who “reduced salt intake” (table 18).

Reduction observed in Systolic BP readings → Approaches within DASH diet ↓	1-3mm /Hg	3-7mm /Hg	7-10mm /Hg	>10mm /Hg	Total
following DASH diet	10 (21.28%)	26 (55.31%)	8 (17.02%)	3 (6.38%)	47
reducing sugar intake	6 (30%)	12 (60%)	1 (5%)	1 (5%)	20
increasing fruits, vegetables, nuts, whole grain	12 (25.53%)	22 (46.80%)	10 (21.27%)	3 (6.38%)	47
reducing salt intake	15 (53.57%)	10 (35.71%)	3 (10.71%)	0	28
reducing saturated fatty foods and red meat	4 (16%)	15 (60%)	3 (12%)	3 (12%)	25
increasing intake of potassium rich food	8 (18.18%)	26 (59.09%)	10 (22.72%)	0	44

Table 20: Reduction in Systolic BP readings found by dietitians in their patients

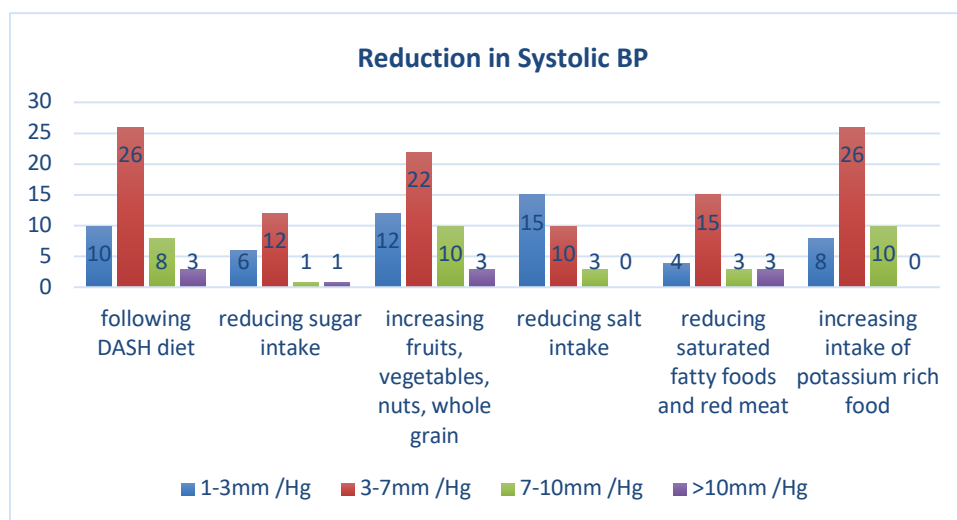


Fig 13: Reduction in Systolic BP readings found by dietitians in their patients

Reduction observed in systolic BP readings → Approaches within DASH diet ↓	1-3mm /Hg	3-7mm /Hg	7-10mm	>10mm /Hg
following DASH diet	-0.511	4.157	-1.094	-2.553
reducing sugar intake	0.447	3.130	-1.789	-1.789
increasing fruits, vegetables, nuts, whole grain	0.073	2.990	-0.511	-2.553
reducing salt intake	3.024	1.134	-1.512	-2.646
reducing saturated fatty foods and red meat	-0.900	3.500	-1.300	-1.300
increasing intake of potassium rich food	-0.905	4.523	-0.302	-3.317

Note: Significant positive values (> +1.96) are in yellow.

Table 21 The heat map for the standard residuals calculated for each approach independently

Slight reduction (1-3mmHg) in DBP was observed when DASH diet was followed in general as well as when each of the independent approaches were followed independently (table 22).

Reduction observed in Diastolic BP readings → Approaches within DASH diet ↓	1-3mm /Hg	3-5mm /Hg	>5mm /Hg	Total
following DASH diet	26 (55.31%)	18 (38.29%)	3 (6.38%)	47
reducing sugar intake	13 (65%)	6 (30%)	1 (5%)	20
increasing fruits, vegetables, nuts and whole grain	32 (68.08%)	12 (25.53%)	3 (6.38%)	47
reducing salt intake	25 (89.28%)	3 (10.71%)	0	28
reducing saturated fatty foods and red meat	15 (60%)	7 (28%)	3 (12%)	25
increasing intake of potassium rich food	25 (56.81%)	18 (40.90%)	1 (2.27%)	44

Table 22: Reduction in diastolic BP readings found by dietitians in their patients

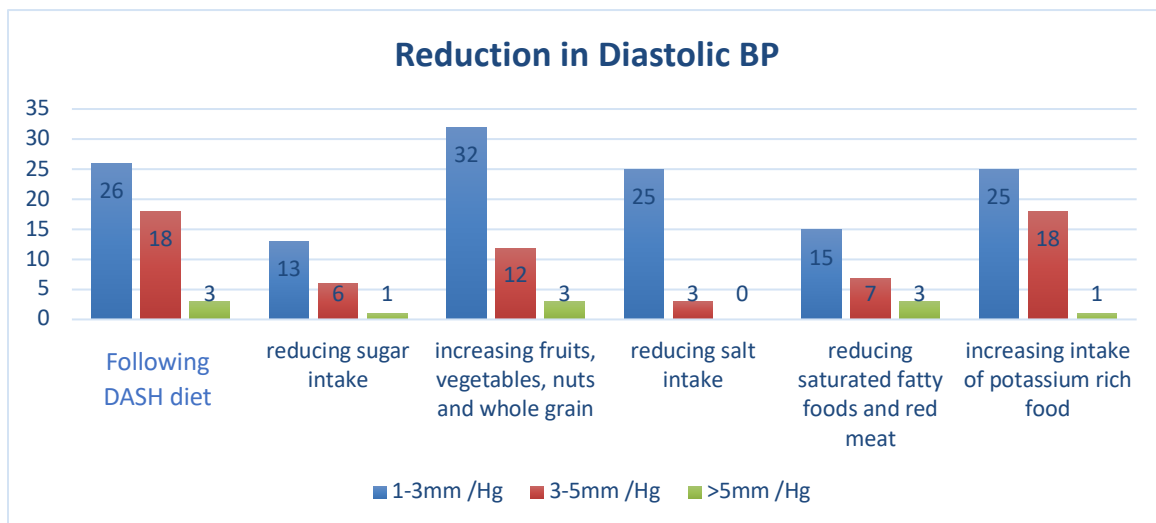


Fig 14: Reduction in diastolic BP readings found by dietitians in their patients

The heat map for the standard residuals calculated for each approach independently is shown in table below:

Reduction observed in diastolic BP readings → Approaches within DASH diet ↓	1-3mm /Hg	3-5mm /Hg	>5mm /Hg
following DASH diet	2.61	0.59	-3.20
reducing sugar intake	2.45	-0.26	-2.19
increasing fruits, vegetables, nuts, whole grain	4.13	-0.93	-3.20
reducing salt intake	5.13	-2.07	-3.06
reducing saturated fatty foods and red meat	2.31	-0.46	-1.85
increasing intake of potassium rich food	2.70	0.87	-3.57

Note: Significant positive values (> +1.96) are in yellow.

Table 23: The heat map for the standard residuals calculated for each approach independently

Table 24 summarizes the reduction in BP readings observed by the dietitians in their patients who followed DASH diet in general and in those who adhered to each of the five approaches to DASH diet independently.

Reduction observed in BP readings → Approaches within DASH diet ↓	Significant no. of patients see reduction	Most occurring Systolic BP reduction				Most occurring Diastolic BP reduction		
		1-3mm /Hg	3-7mm /Hg	7-10mm /Hg	>10mm /Hg	1-3mm /Hg	3-5mm /Hg	>5mm /Hg
following DASH diet	✓		✓			✓		
reducing sugar intake			✓			✓		
increasing fruits, vegetables, nuts and whole grain	✓		✓			✓		
reducing salt intake		✓				✓		
reducing saturated fatty foods and red meat			✓			✓		
increasing intake of potassium rich food	✓		✓			✓		

Table 24: Reduction in BP readings found by dietitians in their patients

Of all the various approaches in DASH diet we analysed and compared between the easiest approach of DASH diet according to the patients, and the most effective approach according to observations by physicians and dietitians. According to the observations by Physicians and dietitians both, following DASH diet was successful in controlling hypertension.

Of the 171 patients following DASH diet, 4 patients (2%) found none of the approaches as easy to follow. For the remaining 167 patients, the below were the easiest approaches to follow:

Easiest approach in DASH diet	% of patients
Increase in fiber rich fruits, vegetables, nuts, whole grains	22%
Increase in potassium rich foods	29%
Reduction of saturated fatty foods, red meat	6%
Reduction of sugar rich foods	22%
Reduction of salt rich foods	21%

Table 25: Easiest approach as per patients

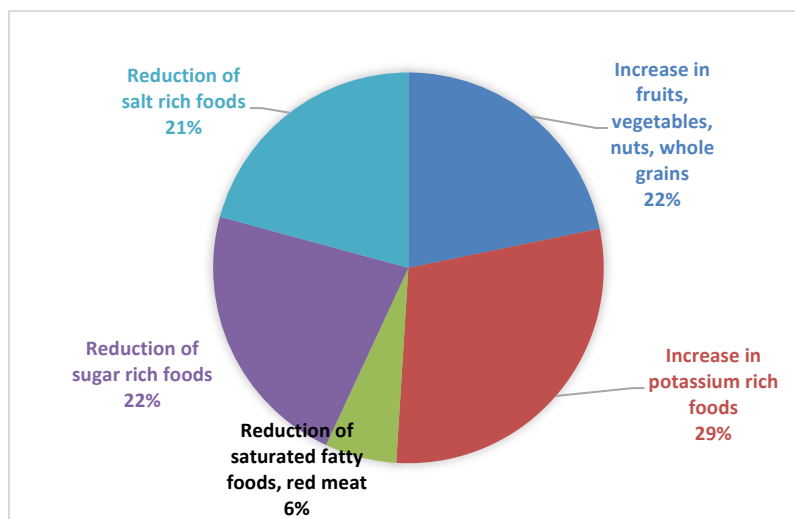


Fig 15: Easiest approach as per patients

We employed the Chi-Square Goodness of Fit Test for the following table of observations ($\chi^2 = 58.87$; $p = 5.01 \times 10^{-12}$)

Easiest approach in DASH diet	# of patient selections
Increase in fiber rich fruits, vegetables, nuts, whole grains	88
Increase in potassium rich foods	118
Reduction of saturated fatty foods, red meat	24
Reduction of sugar rich foods	90
Reduction of salt rich foods	84
Total	404

Note: The total is 404 selections by patients and not 167 patients, as patients could select multiple approaches as easiest for them. For the purpose of the study, we take the selections as independent of each other.

Table 26: Patient observations on easiest approaches

We observed that there is significant evidence that not all approaches are equally easy and that at least one approach stands out as significantly easier or harder for patients to follow. According to the observations of the patients, we found that the easiest approach to DASH diet was “Increase in potassium rich foods like bananas, oranges, melons, broccoli, mushrooms, peas.” This approach was proved as significantly effective in controlling hypertension in both observations of physicians and dietitians. Also, the most significantly seen reduction in systolic BP reading for this approach was moderate (3-7mm /Hg for dieticians) to high (7-10mm /Hg for physicians). This approach also shows definite reduction in diastolic BP readings, albeit slightly (1-3mm /Hg).

Sustainability of DASH diet and the challenges faced by the patients was also evaluated.

Of the 171 patients who followed DASH diet, 7 (4%) felt that DASH diet wasn't sustainable for long duration. 103 (60%) patients felt confident of sustaining the diet, and 61 (36%) were not sure. Again, out of the 171 patients, 57 (33%) patients admitted that they faced challenges while following DASH diet, while the remaining 114 (67%) patients said no challenges were faced.

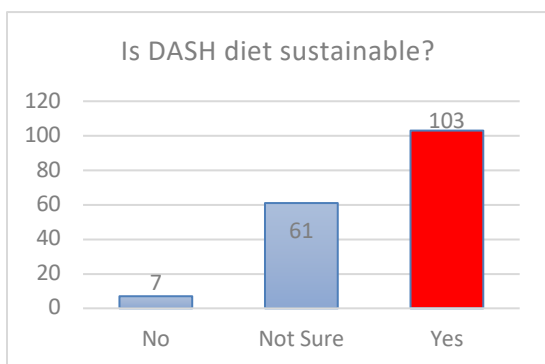


Fig 15: Sustainability of DASH

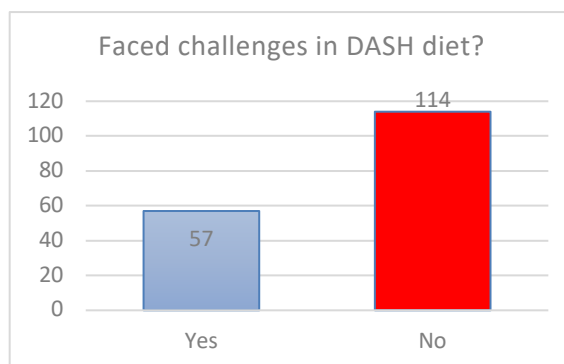


Fig 16: Challenges faced in following DASH

Further analysis of the 57 patients who faced challenges, the following table lists the most common challenges, and the number of times, patients selected them:

Challenges faced by patients in following DASH diet	# of patient selections
Poor availability and quality of fresh fruits and vegetables nearby	3
Healthier food choices are expensive	27
Cooking separate diet meal is a challenge	16
DASH menu included many food items which are not part of our cuisine	24
Limited options to eat healthier food in restaurants	34
Total	104

Note: The total is 104 selections by patients and not 57 patients, as patients could select multiple challenges in following the DASH diet. For the purpose of the study, we take the selections as independent of each other.

Table 27: Challenges faced in following DASH

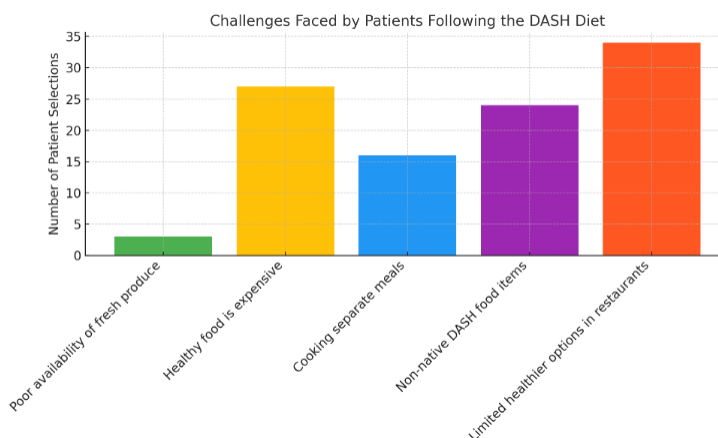


Fig 17: Challenges faced in following DASH

With respect to the 48 physicians, 23 (47.91%) of them felt that the diet was sustainable and 5 (10.41%) of them felt that the diet wasn’t sustainable, while the remaining 20 (41.66%) of them were not sure. Of the 23 physicians who felt that the diet was sustainable, 11 felt that it was sustainable because the diet was “trackable and measurable”, while the remaining 12 felt it was because the diet was “easy to follow”.

The 25 physicians who did not feel that DASH diet was sustainable (or were not sure that it was sustainable) cited the following reasons for unsustainability.

According to physicians, challenges faced by patients in following DASH diet	# of physician selections
Cooking separate diet meal is a challenge	10
DASH menu included many food items which are not part of our cuisine	10
Healthier food choices are expensive	15
Poor availability and quality of fresh fruits and vegetables nearby	9
Limited options to eat healthier food in restaurants	13

Note: The total is 57 selections by physicians and not 25 physicians, as the physicians could select multiple challenges.

Table 28: Challenges faced by patients according to physicians

With respect to the 49 dietitians who were aware of DASH diet, 28 (57.14%) of them felt that the diet was sustainable. 6 (12.24%) of them felt that the diet wasn't sustainable, while the remaining 15 (30.61%) of them were not sure. Further the 49 dietitians were asked whether their patients felt following DASH diet difficult. 21 of them said that their patients found it difficult to sustain DASH diet, while 28 of them said no. Findings are summarized below :

Patients found sustaining DASH diet difficult → Dieticians feel Dash diet is sustainable ↓	No	Yes	Total
Yes	20	8	28
Not Sure	7	8	15
No	1	5	6
Total	28	21	49

Table 29: Sustainability of DASH diet in dietitian cohort

Of the 28 dietitians whose patients felt that the diet was sustainable, 13 felt that it was sustainable because the diet was “trackable and measurable”, while the remaining 15 felt it was because the diet was “easy to follow”. The 21 dietitians whose patients found sustaining DASH diet difficult were asked the reasons. Following are the reasons selected by them.

According to dieticians, challenges faced by patients in following DASH diet	# of dietician selections
Cooking separate diet meal is a challenge	10
DASH menu included many food items which are not part of our cuisine	11
Healthier food choices are expensive	8
Poor availability and quality of fresh fruits and vegetables nearby	5
Limited options to eat healthier food in restaurants	10

Note: The total is 44 selections by dieticians and not 21 dieticians, as the dieticians could select multiple challenges.

Table 30: Challenges faced by patients in following DASH in dietitian cohort

While physicians and dieticians felt that there was no significant difference in the challenges faced by patients in following DASH diet, the Patients themselves felt that the easiest challenge was “Poor availability and quality of fresh fruits and vegetables nearby”, while the most difficult was “Limited options to eat healthier food in restaurants”.

The use of technology (smart apps/trackers) in management of hypertension was evaluated among the three cohorts.

In the patient cohort, out of the 171 patients who followed DASH diets, 159 (93%) used diet tracker or smart app to help them adhere to DASH diet. The responses from the patients are summarised below

Does diet tracker / smart app help in adhering to DASH diet?	# of patients
Never	7
Rarely	32
Sometimes	57
Often	38
Almost Always	25
Total	159

Table 31: Responses of patients on diet tracker

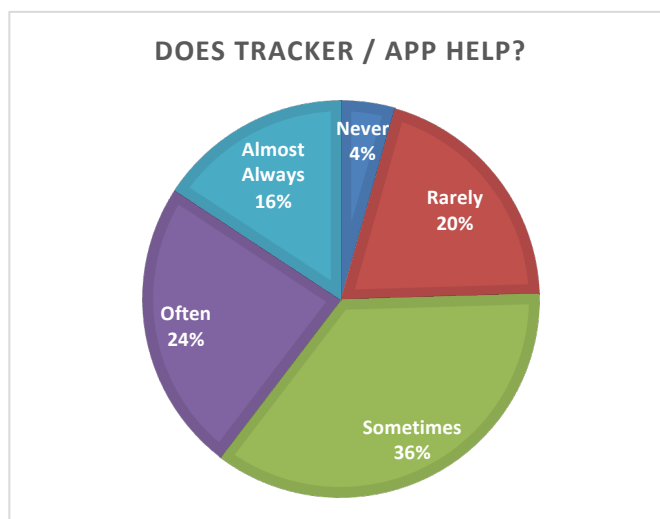


Fig 18: Responses of patients on diet tracker

Similar trend was seen in physician and dietitian cohort. Of the 48 physicians, 36 (75%) felt that use of diet tracker/ smart app helped patients in adhering to, and managing the diet. Responses from the physicians regarding to what extent they helped has been summarised below

Extent to which trackers / smart apps help	# of physicians
Rarely	3
Sometimes	14
Often	19
Almost Always	12
Total	48

Table 32: Responses of physicians on tracker



Fig 19: Responses of physicians on diet tracker

A similar percentage of dietitians, 37 of 49 (76%) too felt that use of diet tracker/ smart app helped patients in adhering to the diet, and managing it better. The extent to which these trackers / smart apps helped patients is summarised below

Extent to which trackers / smart apps help	# of dieticians
Never	2
Rarely	14
Sometimes	22
Often	10
Almost Always	2
Total	50

Table 33: Responses of dietitians on tracker

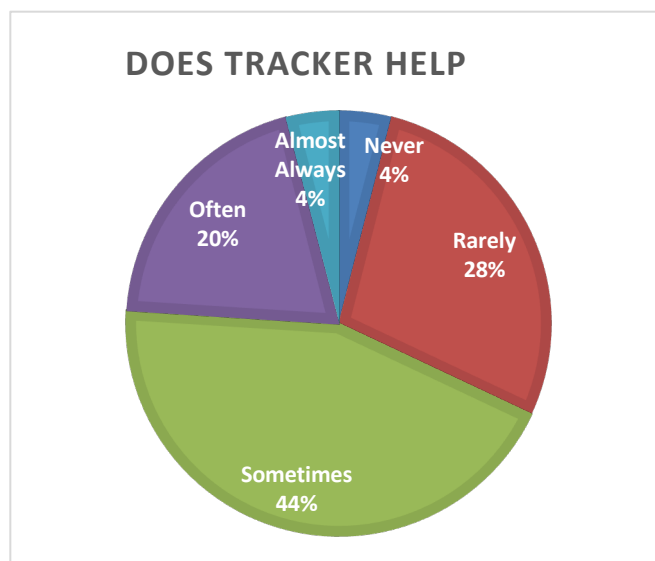


Fig 20: Responses of dietitians on diet tracker

Among patients, a significant proportion of them felt that smart apps and diet trackers helped them only sometimes to adhere to DASH diet. However, according to the physicians, these trackers often helped patients in adhering to DASH diet and managing it and according to the dietitians, these trackers only helped sometimes in adhering and managing the diet.

Discussion

This study analysed the effect and impact of DASH diet in management and control of hypertension in hypertensive patients. Among the cohort of patients who were recruited in this study it was observed that majority of the patients didn't know about DASH diet and their benefits. Of those who were aware of the benefits of the DASH diet, majority were fairly aware of its role in lowering blood pressure, while not many were aware of the benefits of this diet in reduction of the risk of heart disease. The physicians enrolled in the study reported that around 50% of their patients were not aware of the diet, hence they personally felt that more awareness about the diet still needs to be created which was similar to the results observed in Park et al study [14]. Our study showed that there is lack of awareness of the benefits of diet in the general Indian population. However, dietitians reported that the awareness of DASH diet among the patients visiting them was spread across often, sometimes and never.

Similar to previous studies, our study too found that DASH diet was associated with reduction in both systolic and diastolic BP readings. Majority of the patients in the patient cohort saw a moderate reduction (3-7mmHg) in SBP and a fairly low reduction (1-3mmHg) in DBP readings. Similar reduction was observed in the patients who visited the physicians and dietitians enrolled in the study. This finding was similar to that observed in previous studies which showed a reduction in SBP in range of 4.9-7.6mmHg and DBP in range of 2.6-4.2mmHg [15,16].

Most of the patients who took part in the study said that they either just started the diet or started following it only in the past 6 months. Very few patients (14%) said that they were following the diet for more than 1 year, the exact duration however wasn't captured in this study. Patients following DASH diet saw reduction in their BP in both systolic and diastolic readings. Patients who followed the diet for more than a year showed >7mmHg reduction in SBP and >3mmHg reduction in DBP when compared to 1-3mmHg reduction in SBP and DBP in patients who just started with the diet. It was observed longer the adherence to DASH diet, higher was the likelihood of experiencing substantial BP reductions. Around 69% of the physicians who were part of this study saw reduction in BP readings of varying degrees in their patients who were following DASH diet. The reduction in both systolic and diastolic BP readings were evenly spread, with almost equal number of patients seeing low to medium to high reductions. This finding was similar to the findings of earlier studies which showed reduction in BP readings in patients following DASH diet [10,17].

Apart from seeing reduction in BP readings in patients who followed DASH diet completely, physicians also saw reduction in BP readings when independent approaches of DASH diet were followed. Within the five independent approaches of DASH diet, physicians saw significant reduction in BP reading for their patients who "reduced their salt intake", "reduced saturated fatty foods and red meat", or "increased intake of potassium rich food". The findings with respect to red meat suggests a correlation with a similar study done

by German Institute of Human Nutrition where they found a positive association between risk of hypertension and red meat intake [18]. However, they did not see significant reduction in BP readings in their patients who “reduced sugar intake”, or “increased fruits, vegetables, nuts and whole grains” only. This was in contrast to the findings found in earlier study done by Lukas¹⁸. The reduction observed in systolic BP was moderate (3-7mm /Hg) for patients who “reduced salt intake”, while it was observed to be a higher reduction (7-10mm /Hg) in patients who “reduced saturated fatty foods and red meat” and who “increased intake of potassium rich food”. For diastolic BP, the Physicians observed slight reduction (1-3mm /Hg) in their patients who “reduced salt intake”, or “reduced saturated fatty foods and red meat” only.

Dietitians too saw similar reduction in BP readings in their patients following DASH diet in general. Within the five independent approaches of DASH diet, dietitians saw reduction in BP reading in their patients who “increased fruits, vegetables, nuts and whole grains”, or “increased intake of potassium rich food”. However, they did not significantly see reduction in BP readings in their patients who “reduced their salt intake”, “reduced sugar intake”, or “reduced saturated fatty foods and red meat”. Although the earlier studies [10,17] showed significant reduction in BP readings at lower sodium intake our survey study didn’t show significant reduction in BP readings with respect to reduced salt intake. However, with respect to fruits, vegetables, nuts and whole grains our findings were similar to the findings in earlier study wherein an inverse relationship between risk of mortality and increase in fruit and vegetable intake was seen [18].

A moderate reduction (3-7mm /Hg) in systolic BP was observed by the dietitians in their patients who followed DASH diet in general, and also in patients who adhered to independent approaches of “increased fruits, vegetables, nuts, whole grains”, or “increased intake of potassium rich food”. Dietitians also observed a slight reduction (1-3mm /Hg) in diastolic BP in their patients who followed DASH diet in general, as well as when each of the independent approaches were followed independently.

Majority of the dietitians (98%) who were recruited in this study were aware of DASH diet. However, the awareness amongst the patients who visited these dietitians was of varying nature. This finding was similar to that observed in previous studies where the awareness of the diet was varied based on location, education and gender [12,13]. Majority of dietitians (57%) always recommended their hypertensive patients to follow DASH diet and 43% recommended the diet only sometimes. The reason why it was recommended only sometimes was not captured in this study.

DASH diet was found to be effective in controlling hypertension as per the observations by the physicians and dietitians. Patients recruited in this study felt that increasing potassium rich foods like bananas, oranges, melons, broccoli, mushrooms, peas, etc was the easiest approach in DASH diet, while reduction of saturated fatty foods and red meat was the most difficult approach in DASH diet. This trend could be because of the easier availability of potassium rich foods (like bananas, oranges, melons, broccoli, mushrooms, peas, etc) and

fatty saturated foods (like chips, sweets, pastries, biscuits etc) at the same time. This finding was similar to the study done by Tyson et al which showed that the easiest approach to follow was vegetables and fruits and the most difficult approach was sweets and added sugars [25].

Adhering to a diet for longer period of time is a common challenge faced by most patients. Hence a question regarding diet sustainability was included in our questionnaire to understand if DASH diet was sustainable for Indian population. Although only very few patients enrolled in this study followed the diet for more than a year, a significant proportion (60%) of patients who followed DASH diet, felt confident about sustaining the diet over a long period of time. Although physicians and dietitians felt that there is no significant difference in the challenges faced by patients in following DASH diet, the patients themselves felt that the easiest challenge was “Poor availability and quality of fresh fruits and vegetables nearby”, while the most difficult was “Limited options to eat healthier food in restaurants” clearly showing that getting access to good quality of fruits and vegetables is not a challenge any more in India. The patients felt the diet was sustainable because it was easy to follow and was trackable/measurable. However, the patients who found the diet unsustainable felt that cooking separate diet meal was a challenge, DASH diet menu had many items which were not part of their daily food habits, cooking/eating healthier food choices was expensive, and there was poor availability of quality fruits and vegetables. None of these challenges were disproportionately experienced by the patients in following DASH diet. The findings were similar to previous survey study conducted on African Americans [24].

Patients and dietitians felt that trackers and smart apps sometimes helped in adhering to DASH diet. This finding shows that trackers cannot be relied upon always, indicating the need for having more efficient and reliable tools. This finding was similar to the ones found in earlier studies indicating the need for further research to provide high quality evidence to determine the effectiveness of smartphone apps [6,26]. However, physicians welcomed the use of trackers / smart apps in adhering and managing DASH diet well. They felt that it often helped their patients in adhering to the diet better and correspondingly lower the BP readings. These findings were similar to the previous study done on effectiveness of mobile apps in self-management of hypertension [27].

Limitations

Since this was a survey based observational study, the data collected is as reported by the patients, physicians and dietitians. The sample size of individual cohorts was small, hence the results regarding the effectiveness of DASH diet cannot be generalised in each cohort. The responses given by the physicians and dieticians about the patient experiences (extent of reduction in BP after following DASH diet) is based on the physicians' and dietitians' perceptions which may deviate from the patients' actual experiences. This study found that DASH

diet was effective in reducing the SBP and DBP readings. If this effect was purely due to diet alone or in combination with other confounding factors (like medication, supplements, exercise or other lifestyle modifications) could not be ascertained.

Conclusions

This study showed that DASH diet is effective in reducing and managing high blood pressure. The effectiveness of DASH diet from the perspective of patients, dietitians and physicians was captured indicating that for successful implementation of DASH diet there must be a collaboration between different stakeholders like clinicians, dietitians etc. Results of this study clearly highlights the lack of awareness among the general patient population regarding this dietary intervention method and these findings can help in implementing awareness campaigns as a public health initiative so that people can get frequent checkups done and if diagnosed with hypertension can follow measures to control and manage high blood pressure.

The study clearly showed how including different nutrient groups in the diet can have an overall impact on blood pressure readings. Thereby one can consider increasing the intake of certain micronutrients and decreasing the intake of some macronutrients in order to improve the overall well-being of an individual.

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