Original Article

High Prevalence of Prehypertension and its Association with Modifiable Risk Factors: Findings of Household STEPS Survey from Urban Puducherry, South India

Abstract

Background: Prehypertension increases the likelihood of hypertension, cardiovascular diseases, and renal failure, and it is amenable to control if it is detected early. The burden of prehypertension prevalent in the community is not much explored. This study aimed to estimate the prevalence and to identify the socio-behavioral and dietary factors related to prehypertension in South India. **Methods:** A community-based cross-sectional study was carried out where data related to socio-demographic status, substance use, dietary patterns, physical activity, and associated comorbidities were assessed using the WHO STEPwise survey tool. Adults aged >=18 years who were not previously diagnosed and treated for hypertension were assessed for prehypertension. Prevalence of prehypertension is reported as percentage with 95% CI. Association was reported as adjusted prevalence ratio obtained through multivariable log binomial regression adjusted for potential confounders. **Results:** Among 2399 participants, 2213 underwent screening. Among 2213 adults, 810 (36.6%, 95% CI: 34.6–38.6%) were in the prehypertension range. The adjusted prevalence for prehypertension was 36.2% among males and 37.2% among females, respectively. Being in the age group of 45–54 years aPR-1.36, body mass index (BMI) >23 Kg/m^2 aPR-1.25, consumption of more than 6 grams of salt per day aPR-1.15 times were more likely to be associated with prehypertension. The comorbid conditions such as diabetes are less likely to be associated with prehypertension aPR-0.54 (0.41–0.72). **Conclusions:** This community-based surveillance showed 36% of prehypertension among adults which would have been missed if we were to follow the routine cares such as opportunistic and high-risk-based screening. Since prehypertension increases the risk for various end organ failures, there is an impending need to focus on screening and promote healthy lifestyles.

Keywords: *Cardiovascular diseases, early diagnosis, epidemiology, mass screening, prehypertension, public health surveillance*

Sitanshu Sekahr Kar, Kalaiselvi Selvaraj[1], Gomathi Ramaswamy[2], K. C. Premarajan, Ganesh Kumar Saya, Vinodhkumar Kalidoss[3]

Department of Preventive and Social Medicine, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India, [1]Department of Community Medicine, All India Institute of Medical Sciences, Nagpur, Maharashtra, [2]Centre for Community Medicine, All India Institute of Medical Sciences, New Delhi, India, [3]Department of Community and Family Medicine, All India Institute of Medical Sciences, Mangalagiri, Andhra Pradesh, India

Sitanshu Sekhar Kar: https://orcid.org/0000-0001-7122-523X
Kalaiselvi Selvaraj: https://orcid.org/0000-0002-0596-0495
Vinodhkumar Kalidoss: https://orcid.org/0000-0002-1393-6209

Address for correspondence:
Dr. Kalaiselvi Selvaraj, Department of Community Medicine, All India Institute of Medical Sciences (Nagpur), Hanuman Nagar-Nagpur, Maharashtra, India.
E-mail: kalaiselvi.dr@gmail.com

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Introduction

High blood pressure (BP) is one of the major public health challenges as it caused 9.4 million deaths and 7% of the total disease burden in the year 2010. Considering the devastating impact of raised BP, global non-communicable diseases (NCDs) plan of action had endeavored to achieve "25% relative reduction in the prevalence of raised blood pressure" by 2025.[1] Hypertension is a life-time lifestyle disease which could affect the individual without showing any symptoms.

Evidence from Framingham heart study showed around 37% of adults and 50% of elderly having high normal BP which can lead to the progression of prehypertension to hypertension in four years.[2] In view of continuum of risk in vascular complications due to raised BP, for the first time American Joint National Committee (JNC) VII has identified a separate category called prehypertension.[3] According to this guideline, a systolic BP range of 121–139 mmHg and/or a diastolic BP range of 81–89 mmHg is defined as prehypertension.[4] The current American College of Cardiology (ACC)/American Heart Association (AHA) guidelines have also identified the importance of initiating early lifestyle interventions for raised BP (systolic 120–139 mmHG and/or diastolic BP of 80–89 mmHg). Prehypertension increases the likelihood of cardiovascular diseases and renal failure.[5,6] Prehypertension is attributed

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to the cause for 62% of cardiovascular diseases including 49% ischemic diseases. Despite the asymptomatic nature of prehypertension, it is able to deteriorate the contractile function of the heart through various structural alterations and remodeling of heart.[7]

Considering the scope for mitigating the effect of prehypertension many lifestyle experiments are tried in the past.[8] The Dietary Approach to Stop Hypertension (DASH) trial had reported the average reduction of 6 mmHg systolic BP and 3 mmHg diastolic BP over an eight-week period while on a fruit- and vegetable-rich, low-salt and low-fat diet.[9] A health trial by Hageman *et al*. had reported intervention in the form of distant, theory-based lifestyle modifications among women with prehypertension. In this study, at the end of six months, 50% of prehypertensive women who received web-based lifestyle interventions had attained normotensive status. Similarly, 40% of the women who received interventions through print media became normotensive at the end of six months. These normotensive effects were found to sustain up to two years.[10] The results of a premier trial which included comprehensive interventions namely sodium reduction, weight loss, and increased physical activity showed reduced overall cardiovascular risk among prehypertensive individuals.[11] Following the stress reduction technique among prehypertensive adults has also been found to decrease 4.8 and 1.9 mmHg of systolic and diastolic BP, respectively.[12] All these intervention trial results show the promising effects of lifestyle intervention among prehypertension patients without any need for pharmacological therapy.

In India, 25.6% of the population is estimated to have raised BP contributing to 52% of NCD mortality among adults less than 70 years old.[1] Although few studies from India have attempted to estimate the impact of prehypertension, those studies were limited in application because of their focus on opportunistic screening in facility-based and industrial settings, thereof the majority participatory population being young adult males.[13-19] Moreover, previous studies have reported the variations based on demographic characteristics and studies which looked into the role of behavioral and lifestyle factors in prehypertension are scarce.

Therefore, we planned to estimate the burden of prehypertension and the socioeconomic, behavioral, and lifestyle factors associated with it in a community-based urban setting of Puducherry region.

Methods

Study design

This was a cross-sectional study conducted as part of an NCD surveillance project.

Target population

This study was conducted in four urban wards functioning under a tertiary care center in one of the union territories from South India. The study area caters to the population of around 10,000. In this urban setting, the majority of the adults are employed as skilled and semiskilled labors. The study area is located in the heart of the city where access to markets, transport, and healthcare facilities are maximum.

A house-to-house survey method was used to approach adults who are 18 years or more. Regardless of their previous history of hypertension, adults aged 18 years and above were considered as eligible participants in this study.

Sample size and sampling methods

This study was a part of a main study which primarily focuses on hypertension and other related risk factors. Details of the study methods and findings are reported elsewhere.[20] Based on the assumptions of prevalence of hypertension for Puducherry (p) as 12.2%,[21] 15% relative precision (d = ~1.83%), 95% CI (Z), and design effect (DEFF) 2, the estimated sample size obtained in Open Epi using the formula n = [DEFF*Np (1-p)]/[($d^2/Z^2_{1-\alpha/2}$*(N-1)+p*(1-p)] was 2096. Bearing in mind the nonresponse rate of 10%, the required sample size was found to be 2305. Based on the census enumeration of the study area, the number of adults aged 18 years and above was found to be around 2400. Hence, without any further sampling, universally all eligible adults (18 years or more) from the study area were surveyed using a structured STEP wise approach to Surveillance (STEPS) survey tool.[22] If the eligible participants cannot be contacted during the initial survey, two additional visits were made to contact the participants. Those who could not be contacted even after the two additional visits were excluded from the study. BP was measured twice in their house using automated electronic BP apparatus (Omron BP785 10 Series) in sitting posture with a 10-min interval on the same day of interview.[4] Averages of both the readings were used for estimating the BP. Participants with a systolic BP of 120–139 mmHg and/or a diastolic BP of 80–89 mmHg and not a case of previously diagnosed and treated for hypertension were defined as having prehypertension.

The burden of hypertension and other related risk factors measured through STEPS surveillance are reported in detail elsewhere.

Data collection

Data regarding participant characteristics [age, gender, education, occupation, income] and risk factors related to NCDs [alcohol and tobacco use, physical activity, high salt intake, consumption of fruits and vegetables] were collected as per the WHO STEPS surveillance tool.[22] Operational definitions used for classifying various NCD-related risk factors are given in Table 1. Participant weight, height,

Table 1: Operational definitions followed in the assessment of cardiovascular disease risk factors in South India 2015-2016

Risk factor	Definition
Diabetes Mellitus/Hypertension	Study participants reported to have these illnesses by any health care providers in the past or currently taking medications such as oral hypo glycemic agents, insulin, anti hypertensives, aspirin, and other anti-platelet drugs
Tobacco (current use)	Any person at the time of the survey, smokes/uses tobacco in any form either daily or occasionally
Alcohol use (current use)	Those who consumed one or more than one drink of any alcohol (any standard drink with net alcohol content of 10 gm ethanol) in the year preceding the survey
High Waist circumference	>100 cms in male and >90 cms in female
Overweight	BMI 23-24.9 kg/m^2; obesity: BMI 24.9 kg/m^2 and above
Physical inactivity	<600 metabolic equivalents (METs) based on cumulative physical activity (work, transport, and leisure time related) in a week prior to the survey
High salt intake	Household per capita salt consumption >6 gms/day
Inadequate fruits and vegetables intake	Less than five servings of fruits and vegetables (~80 gms) intake per day during the week of the survey

Prevalence of prehypertension = [number of adults whose systolic BP 120-139 mmHg &/diastolic BP 80-89 mmHg and not currently on treatment for hypertension or previously diagnosed as a case of hypertension]*100/number of adults 18 years and above

and waist circumference were measured according to standard guidelines.[23] The weights of the participants were measured using a bathroom scale with 100 gms of least accuracy. The heights were measured using a stadiometer in a standing posture with bony prominence such as heel, buttock, shoulder, and occiput touching the surface. Waist circumference was measured at the umbilicus and hip circumference was measured at the level of anterior–superior iliac spine over the clothing.

Data management

Data were entered in Microsoft Excel 2007 and analyzed using EpiData (EpiData Analysis v2.2.2.2.183, EpiData Association, Odense Denmark).[24] The characteristics of the participants such as gender, education, occupation, NCD risk factors, and key variable on prehypertension status are reported as proportions. Factors associated with prehypertension were tested using chi square test and the associations were measured in terms of prevalence ratio. To build adjusted model estimates, a *P* value of <0.1 and other factors which have proven the strong biological plausibility from the past evidences were considered. The adjusted estimates on prevalence ratio were obtained through a log binomial regression using STATA 11 (Statacorp, college station, University of Texas, Chicago).[25] The adjusted estimates for risk factors related to prehypertension are presented as adjusted prevalence ratio with 95% CI. Since some of the subgroups had significantly different overall prevalence ratios compared to sex-specific estimates, the interaction of sex with other demographic and behavioral characteristics are tested. Since few variables such as tobacco use had a different impact on the prevalence of prehypertension, gender-specific adjusted rates of prehypertension are presented. This study was approved by institutional ethics committee.

Results

Totally, 2399 individuals above the age of 18 years were selected for this study. Among them, BP of 186 participants could not be recorded despite repeated household visits and, therefore, the response rate of this research declined to 93%.

The majority of participants were female (59.1%), literates (83.0%), Hindu by religion (84%), and belong to lower socioeconomic status (55.5%). Other socio-demographic characteristics are provided in Table 2.

Among 2399 participants, 8.2% and 12.4% reported the history of using tobacco products and alcohol during their lifetime, respectively. Among the tobacco using participants, 78% were currently using tobacco. Similarly, 92.3% of the alcohols using participants are currently using alcoholic products [Table 2]. The female participants had higher BMI [mean (SD): 25.2 (4.5)] than male participants [mean (SD): 24.2 (4.1)] [$P < 0.001$].

The mean (SD) age of initiation of tobacco usage was 21.7 (7.7) years and median (IQR) years was about 20 (10–45) years. Almost all participants (97.7%) consumed inadequate quantities of fruits and vegetables every day.

Of the 2311 individuals screened, a total of 779 individuals had hypertension: 367 already diagnosed hypertension and 412 diagnosed as hypertension at the time of the study. Total of 810 adults had their systolic BP of 120–139 mmHg and or diastolic BP of 80–89 mmHg. The overall age-adjusted prevalence of prehypertension was 36.2% (95% CI: 34.4%–38%) among males and 37.2% (95% CI: 35.7%–38.6%) among females, respectively. Age-adjusted prevalence of prehypertension in various subgroups is shown in Tables 3 and 4. Among adults who are apparently healthy, not a known hypertensive or having a hypertensive BP, the prevalence was found to be 56.5% (95% CI: 53.9%–59.1%).

Table 5 shows the prevalence of prehypertension and its association with study participants' characteristics using univariate and multivariate regression models. Overall, advancing age (for 45–54 age group: aPR – 1.37 (1.05–1.78); obesity: aPR – 1.22 [1.29 (1.12–1.48)]) and high salt

Table 2: Demographic and behavioral characteristics of adults participated in the STEPS survey of urban Puducherry, 2015-2016

Factor	Male (%)	Female (%)	Number (%)
Age group (years)			
18-24	129 (14.2)	154 (11.8)	283 (12.8)
25-34	193 (21.3)	313 (24)	506 (22.9)
35-44	231 (25.5)	299 (22.9)	530 (24)
45-54	181 (20)	251 (19.2)	432 (19.5)
55-64	107 (11.8)	156 (11.9)	263 (11.9)
65-98	65 (7.2)	134 (10.3)	199 (9)
Education			
Illiterate	91 (10)	290 (22.2)	381 (17.2)
Primary	116 (12.8)	207 (15.8)	323 (14.6)-
Middle	204 (22.5)	292 (22.3)	496 (22.4)
High school	234 (25.8)	265 (20.3)	499 (22.6)
Higher secondary	110 (12.1)	105 (8)	215 (9.7)
Undergraduate	83 (9.2)	75 (5.7)	158 (7.1)
Postgraduate	68 (7.5)	73 (5.6)	141 (6.4)
Below poverty line (BPL) status			
Non BPL	440 (48.7)	541 (41.4)	981 (44.3)
BPL	464 (51.3)	765 (58.6)	1229 (55.5)
Occupation categories			
Unemployed	192 (21.2)	909 (69.5)	1101 (49.8)
Unskilled	63 (7)	125 (9.6)	188 (8.5)
Semi-skilled	442 (48.8)	86 (6.6)	528 (23.9)
Clerical/business	166 (18.3)	154 (11.8)	320 (14.5)
Professional	43 (4.7)	33 (2.5)	76 (3.4)
Life style factors			
Tobacco use	165 (18.2)	16 (1.2)	181 (8.2)
Alcohol use	263 (29)	11 (0.8)	274 (12.4)
Physically inactive	98 (12.9)	206 (18.1)	304 (16)
High salt intake	572 (63.6)	799 (61.2)	1371 (62.2)
Poor consumption of vegetables and fruits	708 (97.9)	1036 (97.6)	1744 (97.7)
Overweight/obesity (BMI >23 kg/m^2)	521 (59.1)	877 (67.8)	1398 (64.3)
Hypertension	359 (39.6)	420 (32.1)	779 (35.2)
Diabetes mellitus	78 (10.8)	112 (10.5)	190 (10.6)
Raised waist circumference	562 (76.6)	769 (70.2)	1331 (72.7)

intake [aPR – 1.20 (1.04–1.39)] were found to be the independent significant factors increasingly associated with prehypertension. Though advancing age and certain occupation categories such as clerical work and business showed increased trends of prehypertension in the univariate model, they did not prove to have an independent association. In the multivariate model, tobacco usage is found to have significant gender-specific influence over the prevalence of prehypertension. Hence, sex-specific adjusted estimates of the prevalence of prehypertension are provided in Supplementary table. The presence of tobacco use among females increased the prevalence of prehypertension by twofold and more, whereas tobacco use did not show any increase among males (male: 0.90 (0.63–1.29); female: 2.34 (1.51–3.62); overall: 1.10 (0.79–1.54). Similarly, although obesity was the significant risk factor among females, no such effects were observed in males [male: 1.15 (0.91–1.46); female: 1.56 (1.6–1.94); overall: 1.29 (1.12–1.48)]. Regardless of the gender, adults who had diabetes mellitus had a low prevalence of prehypertension compared with those without diabetes [(male: 0.43 (0.22–0.82); female: 0.63 (0.43–0.91); overall: 0.57 (0.42–0.74)]. With the exception of interaction between tobacco and sex suggesting a higher prevalence of prehypertension among females in all other subgroups, no significant gender difference was observed [Supplementary Table 1].

Discussion

Prevalence of prehypertension

This community-based surveillance for NCD showed a 36.8% prevalence of prehypertension among adults aged 18 years and above. Certain subgroups such as age beyond 45 years and females who consume tobacco and alcohol

Table 3: Age weighted prevalence of prehypertension by socio-demographic factors among adults from urban Puducherry, 2015-2016

Factor	Male (95% CI)	*P*	Female (95%CI)	*P*
Over All	36.2 (34.4-38)		37.2 (35.7-38.6)	
Education				
Illiterate	39.6 (29.9-50.1)		42.4 (36.8-48.2)	
Primary	32.3 (24.7-41.9)	0.15	37.2 (30.8-44)	0.07
Middle	38.7 (32.2-45.6)		35.3 (30-41)	
High school	41.9 (35.7-48.3)		33.6 (28.1-39.5)	
Higher secondary	37.3 (28.6-46.8)		32.4 (24-42)	
Undergraduate	34.9 (25.3-46)		28 (18.8-39.4)	
Postgraduate	33.8 (23.4-46.1)		26 (17.1-37.5)	
BPL status				
Non BPL	38 (33.5-42.6)	0.9	35.9 (31.9-40)	0.9
BPL	38.1 (33.8-42.7)		35.6 (32.2-39)	
Religion			-	
Hindu	37.6 (34.2-41.1)	0.1	36 (33.2-38.9)	0.65
Christian	42.6 (34.7-51.2)		34.6 (28.1-41.6)	
Muslim	-		16.7 (0.9-81)	
Occupation				
Unemployed	34.3 (27.9-41.4)		36 (33.2-38.9)	
Unskilled	39.7 (28.1-52.5)		36.8 (28.7-45.7)	
Semi-skilled	40.3 (35.8-44.9)	0.11	24.4 (16.3-34.8)	**0.03**
Clerical-business	38.6 (31.4-46.2)		44.1 (36.4-52.1)	
Professional	25.6 (14.4-41.2)		27.3 (14.3-45.7)	

Bold: The actual *P* value itself 0.005 which is lower than 0.05. Hence it is significant

had more than 40% prevalence of prehypertension. Among adults who were considered to be normal or who did not have hypertension in the past or not having hypertensive BP during the survey had more than 56.5% prevalence of hypertension. The prevalence of prehypertension reported in the current study is in line with the estimates reported from other Indian studies, South Asian countries, and other adjacent low-middle income countries (36–47%).[13-15,26-30] Studies which excluded already known and newly diagnosed hypertension cases had shown relatively high prevalence compared with studies which included all participants regardless of their previous hypertension state.

Risk factors related to hypertension

Few studies including the study from India had demonstrated the high prevalence of prehypertension among younger adults compared with older.[16,17] The most possible explanation could be an early adaptation of corrective measures and health-promoting behaviors among older adults who are likely to undergo an opportunistic screening and counseling for lifestyle modifications compared with others. The same phenomenon explains the contradictory observation of low prevalence of prehypertension reported in this study. Depending on the strategies implemented under the national programs and emphasis given under health promotional activities, the scenario could differ. In the system, where program is actively focused on population-based and opportunistic screening, it is expected that majority of the adults are either classified under hypertension group or converted to normotensive stage through lifestyle modifications, thereof clustering of prehypertension among young adults and other subgroups who have comorbid conditions such as diabetes.

In this study, several subgroups such as being in the age group of 45–54 years and obese either by BMI >25 kg/m^2 are significantly associated with prehypertension compared with others. These findings were in similar line with other studies reported.[15] The current study also identified the significant association of various unhealthy dietary practices, for instance, high salt intake (>6 gms/day), less-frequent intake of vegetables and fruits, and frequent intake of fast foods.[14,15] In contrary to observation from other studies, the present study did not show any association with tobacco or alcohol use.[13,15] This could be due to the extensive emphasis given for opportunistic screening among tobacco and alcohol users under the National Programme on Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke, thereby left with less proportions of prehypertensives in the community.

Considering the high risk of conversion of hypertension to cardiovascular diseases compared to the counterparts of adults having normal BP, it is expected that significant numbers are going to be added to the pool of NCDs.[2,3,13] Prehypertension, being a symptomless disease it is largely neglected and overlooked by the family physicians.[26,31] Incidence of hypertension was found to be 2.5 times higher in the prehypertensives compared with the normotensive adults.[32] Moreover, this condition can be easily tackled by health-promotional measures which obviate the need for pharmacological therapy.

Strengths and limitations of the study

This study has several strengths. Unlike other studies which focused mainly on industrial settings, this study is a community-based study and, hence, the generalizability is more. This study highlighted the prevalent prehypertension among adolescents also (adults aged 18 years and above) which is a highly vulnerable group to have prehypertension and often overlooked by the family physicians. Since in this study all the data were collected using a single trained investigator, the interobserver variation is kept low. Since in this study automated electronic machine was used to measure the BP, intraobserver variation is also ruled out. Efforts were made to contact the participants at their convenient time and, hence, the response rate was kept at higher level. This study was carried out as a home-based survey using the comprehensive STEPS surveillance tool.

The study has the following limitations. The definition used in the current study is based on the single day average of

Table 4: Age weighted prevalence of prehypertension by behavioral factors among adults from urban Puducherry, 2015-2016

Factor	Male (95% CI)	*P*	Female (95%CI)	*P*
Tobacco use				
No Tobacco	38.3 (34.9-41.9)	0.63	35.2 (32.7-37.9)	**0.005**
Tobacco	36.7 (29.3-44.1)		68.8 (40.2-87.8)	
Alcohol use				
No alcohol	39.2 (35.5-43)	0.24	35.5 (32.9-38.2)	0.19
Alcoholic	35 (29.4-41)		54.5 (22.6-83.2)	
Physical Activity				
Physically active	38.4 (34.8-42.2)	0.34	36.4 (33.3-39.5)	0.68
Physically inactive	33.7 (24.9-43.7)		37.9 (31.4-44.7)	
Salt consumption				
Low salt	-34.7 (29.9-40.2)	0.13	32.8 (28.8-37)	0.09
High salt	40 (36.1-44.1)		37.4 (34.1-40.8)	
Consumption of fruits and vegetables				
<5 servings/day	33.3 (12.9-62.8)	0.76	19.2 (7.7-40.4)	0.08
>5 servings	37.1 (33.7-40.8)		36.1 (33.2-39.1)	
Obesity				
Normal/under nourished	37.5 (32.6-42.6)	0.43	27.3 (23.3-31.8)	**0.0001**
Overweight/obese	40.1 (40-44.4)		40.1 (36.9-43.4)	
Waist hip ratio				
Normal WHR	39 (31.9-46.5)	0.53	39.8 (34.6-45.2)	0.10
Raised WHR	36.3 (32.4-40.4)		34.6 (31.3-38)	
No hypertension	62.9 (58.7-66.9)	-	52.5 (49.2-55.8)	-
Diabetes				
Not a diabetic	39 (35.3-42.8)	**0.0001**	37.2 (34.2-40.3)	**0.006**
Presence of diabetes	36.3 (32.4-40.4)		34.6 (31.3-38)	

Bold: The actual *P* value itself 0.005 which is lower than 0.05. Hence it is significant

BP measured over a 10-min interval. The JNC 7 guideline classifies hypertension based on BP measured on two occasions. Considering the attrition rate on a subsequent visit in a community-based survey, the decision was made to follow the single-day measure. The cut-off used in the current study (120–139 and/or 80–89 mmHg) is different from the recent AHA/ACC classification. However, these cut-offs were made in accordance with the STEPS protocol to enable the comparison of cross country prevalence. The current study design cannot prove the temporality of association for several factors namely healthy diet, physical activity, and substance use behavior. This study did not include several key variables such as family history hypertension and any family members on treatment with lifestyle modifications. Factors such as per capita salt intake, dietary patterns of regular consumption of fruits and vegetables were assessed based on the participants' report. Probably, the same could be the reason for not getting the statistical significance in these related variables. However, we tried to increase the validity of the reported measure by showing standardized sets of cups with varying serving size.

Implications

This study has several programmatic implications. In total, 37% prevalence of prehypertension which is equivalent to the impending stage of hypertension [the precursor for major killer-cardiovascular diseases] has to be tracked at the earliest stage from the adolescent onwards. Since prehypertension is independently associated with the increased risk of cardiovascular complications and renal failure in conjunction with hypertension, prehypertension should also be included for care under the program. Management of prehypertension does not warrant any pharmacological therapy. Adhering to few lifestyle modifications mentioned under "best buys" such as regular consumption of fruits and vegetables, moderate salt intake, regular physical activity alone can reduce the BP to the extent of the normal range. Since prehypertension can be reversed to a normotensive stage with several lifestyle modifications, the program has to support more health-promotional activities through policies and creating infrastructures. Several vulnerable subgroups such as illiterates, obese, and those who indulge in unhealthy eating behavior have to be guided and managed through specific lifestyle intervention projects. The successful management of prehypertension will illustrate a standard delivery care model to convince the policymakers in reorienting the health system from sickness to wellness care.

Conclusions

This community-based NCD surveillance had shown a 36% prevalence of prehypertension among adults in the

Table 5: Factors associated with prehypertension (prevalence ratio) among adults in urban Puducherry, 2015-2016

Factor[ŧ]	Unadjusted PR	Adjusted PR	*P*[#]
Gender			
Male	Ref	-	
Female	0.94 (0.85-1.05)		0.27
Education			
Illiterate	1.4 (1.06-1.85)	1.41 (0.98-2.05)	0.08
Primary	1.2 (0.89-1.60)	1.13 (0.77-1.65)	0.64
Middle	1.23 (0.93-1.63)	1.33 (0.94-1.88)	0.26
High school	1.26 (0.95-1.66)	1.19 (0.84-1.67)	0.49
Higher secondary	1.17 (0.86-1.6)	1.23 (0.85-1.77)	0.45
Undergraduate	1.06 (0.75-1.50)	0.86 (0.55-1.35)	0.94
Postgraduate	Ref	Ref	-
Occupation categories			
Unemployed	1.34 (0.91-1.97)	1.23 (0.80-1.89)	0.24
Unskilled	1.43 (0.94-2.18)	1.26 (0.78-2.04)	0.46
Semi-skilled	1.44 (0.97-2.13)	1.14 (0.72-1.79)	0.31
Clerical-business	1.57 (1.05-2.33)	1.30 (0.83-2.03)	0.21
Professional	Ref	Ref	
Age group*			
18-24	1.09 (0.84-1.42)	1.28 (0.89-1.85)	0.50
25-34	1.09 (0.86-1.39)	1.13 (0.82-1.56)	0.49
35-44	1.24 (0.98-1.57)	1.19 (0.87-1.63)	0.23
45-54	1.36 (1.08-1.71)	1.47 (1.08-1.98)	0.02
55-64	1.12 (0.86-1.46)	1.09 (0.78-1.53)	0.77
65-98	Ref	Ref	
Tobacco use		-	
Yes	1.08 (0.89-1.31)	1.1 (0.79-1.54)	0.43
Alcohol use		-	
Yes	0.37 (0.35-0.39)	0.91 (0.67-1.23)	0.76
Physical activity		-	
Physically inactive	0.98 (0.35-0.40)		0.82
Salt intake*			
High salt intake	1.15 (1.02-1.29)	1.22 (1.04-1.43)	0.01
Consumptions of fruits and vegetables			
Low	1.50 (0.87-2.58)		0.15
Obesity*			
BMI >23 kg/m^2	1.25 (1.11-1.41)	1.37 (1.17-1.61)	0.0001
Diabetes mellitus*			
Yes	0.54 (0.41-0.72)	0.55 (0.40-0.76)	0.0001
Waist circumference		-	
Raised waist circumference	0.89 (0.78-1.20)		0.09

PR Prevalence Ratio [ŧ]no tobacco use, no alcohol use, physically active, adequate consumption of fruits and vegetables, BMI =<23, No diabetes, normal waist circumference are the reference categories significant factors identified from multivariable model, [#]age, salt intake, obesity, diabetes mellitus - adjusted P obtained from multivariate model; remaining factors - unadjusted *P*

urban union territory. Prevalence is lesser among subgroups such as the elderly population aged 60 years and more and presented with comorbid conditions where the institution of corrective measures are applied in the form of early lifestyle modifications. Several population subgroups namely age 45–54 years, obese, and high salt intake are significantly more likely to be associated with prehypertension, thereby the forthcoming risk of hypertension and cardiovascular diseases. This necessitates the urgent need for emphasizing health-promotional behavior in the community to avoid the impact of hypertension and other cardiovascular diseases on the community.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary Table 1: Factors associated with prehypertension by gender in urban Puducherry 2015-2016

Factor	Male	Female	Both
Illiterate	1.59 (0.89-2.82)	1.33 (0.78-2.25)	1.41 (0.98-2.05)
Primary	0.97 (0.51-1.84)	1.22 (0.72-2.08)	1.13 (0.77-1.65)
Middle school	1.41 (0.85-2.34)	1.35 (0.81-2.23)	1.33 (0.94-1.88)
High school	1.28 (0.78-2.08)	1.21 (0.74-2.0)	1.19 (0.84-1.67)
Higher secondary	1.29 (0.77-2.18)	1.23 (0.72-2.12)	1.23 (0.85-1.77)
Undergraduate	0.93 (0.50-1.73)	0.82 (0.43-1.57)	0.86 (0.55-1.35)
Postgraduate	Ref		
Occupation			
Unemployed	1.32 (0.7-2.5)	1.21 (0.64-2.29)	1.23 (0.80-1.89)
Unskilled	1.28 (0.61-2.7)	1.18 (0.59-2.36)	1.26 (0.78-2.04)
Semi-skilled	1.17 (0.64-2.12)	0.50 (0.20-1.25)	1.14 (0.72-1.79)
Clerical	1.13 (0.60-2.1)	1.32 (0.68-2.55)	1.30 (0.83-2.03)
Professional	Ref		
Age group (Yrs)			
18-24	1.81 (0.85-3.385)	1.20 (0.78-1.86)	1.28 (0.89-1.85)
25-34	2.21 (1.04-4.67)	0.92 (0.62-1.36)	1.13 (0.82-1.56)
35-44	1.84 (0.87-3.91)	1.13 (0.79-1.62)	1.19 (0.87-1.63)
45-54	2.28 (1.07-4.82)	1.38 (0.98-1.93)	1.47 (1.08-1.98)
55-64	1.27 (0.58-2.79)	1.2 (0.83-1.75)	1.09 (0.78-1.53)
65-98	Ref		
High salt intake	1.16 (0.89-1.52)	1.29 (1.06-1.57)	1.22 (1.04-1.43)
Salt intake <6 gms	Ref		
Tobacco use	0.90 (0.63-1.29)	2.34 (1.51-3.62)	1.1 (0.79-1.54)
No tobacco use	Ref		
Alcohol use	0.9 (0.66-1.23)	0.92 (0.45-1.85)	0.91 (0.67-1.23)
NO alcohol use	Ref		
Obese	1.15 (0.91-1.46)	1.56 (1.6-1.94)	1.37 (1.17-1.61)
Underweight/Normal	Ref		
Presence of diabetes Mellitus	0.43 (0.22-0.82)	0.63 (0.43-0.91)	0.55 (0.40-0.76)
No diabetes Mellitus	Ref		
Inadequate vegetables intake	0.66 (0.34-1.29)	1.74 (0.83-3.66)	1.19 (0.71-1.99)
At least five servings of vegetables and fruits in a day	Ref		