

Review Article

The Role of Epidemiological Principles in the Prevention and Control of Hypertension: A Review

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Abstract: Hypertension is the most significant modifiable risk factor for congestive heart failure, peripheral vascular disease, coronary heart disease, stroke and end-stage renal disease and so feeling well doesn't necessarily mean one isn't at risk. This is unfortunately due to the fact that many people are unaware of having the disease not until they have had a cardiovascular event such as stroke or heart attack. Globally, approximately 7.5 million deaths have been accounted for by hypertension, amounting to 12.8 % worldwide mortalities. This review paper aimed at studying the impact of knowledge of the etiology of hypertension as well as the role epidemiological principles in preventing and controlling hypertension targeted at the risk factors which include modifiable risk factors (unhealthy diet, obesity, too much salt and alcohol consumption, excessive smoking, too little potassium in diet among others) and non-modifiable risk factors (age, family history, race/ethnicity, gender among others).

Keywords: Hypertension, heart failure, peripheral vascular disease, coronary heart disease.

INTRODUCTION

Hypertension is a very common disease worldwide affecting humans and has been known to be a major risk factor of other chronic diseases. They include myocardial infarction, stroke, chronic kidney disease and vascular diseases [1]. The etiology of most adult cases of hypertension is still unknown despite extensive research in the past decades. Prevention and treatment of hypertension is of public health significance due to the associated cost, morbidity and mortality to the society [1].

Hypertension is most significant modifiable risk factor for congestive heart failure, peripheral vascular disease, coronary heart disease, and stroke and end-stage renal disease [2]. Therefore, it is imperative that health care professionals do not only identify and treat patients with hypertension but as well promote healthy lifestyles and hypertension prevention strategies aimed at decreasing the distribution and prevalence in the general population.

Etiology of hypertension

Hypertension may be primary, otherwise known as essential hypertension, which develops as a consequence of genetic or environmental causes [3]. Hypertension may also be secondary which has been

reported to have multiple etiologies which include vascular, endocrine and renal causes. Primary hypertension accounts for about 90-95% of cases in adults and secondary HTN accounts for a smaller percentage of 2-10% [3].

Case definition of hypertension

Hypertension is defined as systolic blood pressure (SBP) of ≥ 140 mmHg or diastolic blood pressure (DBP) of ≥ 90 mmHg or a situation where a person is on anti-hypertensive medications even when under control [3].

Clinical signs and symptoms and diagnosis

Signs and symptoms of hypertension

Hypertension usually has no warning signs or symptoms and so many people fail to realize they have it. However, there are cases where people experience signs and symptoms. They come in the form of headache, dizziness, fatigue or weakness in parts of the body (limbs) and blurred visions. A progression of these lead to complications in some organs where more disease manifestations are seen [3].

Diagnosis of hypertension

Blood pressure measurements for adult cases above the age of 18 years include-

Normal: SBP lower than 120 mmHg, DBP lower than 80 mmHg

Prehypertension: SBP 120-139 mmHg, DBP 80-89 mmHg

Stage 1: SBP 140-159 mmHg, DBP 90-99 mmHg

Stage 2: SBP \geq 160 mmHg, DBP \geq 100 mmHg

Sever hypertension: SBP \geq 180 mmHg, DBP \geq 110 mmHg

Treatment

After the diagnosis of HTN has been made, treatment should commence. It may be for life especially for those with cases of essential hypertension. For those with secondary HTN, there are cases of permanent cure after the removal of the cause. In other cases where after the removal of the primary cause, anti-hypertensive treatment is still continued.

Complications

Cerebrovascular disease (Stroke) and heart attack are the most common complications with HTN. These complications are mostly as a result of atherosclerosis, which causes blockage or rupture of blood vessel. Other complications associated with HTN include heart failure, renal impairment, visual

impairment, peripheral vascular disease and retinal hemorrhage.

Morbidity and mortality distribution of hypertension

World Health Organization situation and Trends

HTN has been estimated to cause 7.5 million deaths which is about 12.8% of total mortalities worldwide. This explains for about 57 million disability adjusted life years (DALYS) (3.7% of total DALYS). The overall prevalence of HTP globally in adults aged 25 years and above was about 40% in the year 2008 [4].

Across WHO regions, Africa has the highest HTN prevalence with 46% a combination of both sexes. Both men and women have significantly high rates of HTN in Africa. The lowest prevalence rate of HTN in WHO regions was seen in America with 35% for both sexes. However, men in this region had a higher prevalence of 39 % when compared with the prevalence of women (32%). Men have slightly higher HTN rates in all WHO regions than women. This difference however has been shown to be statistically significant in Americans and Europeans [4].

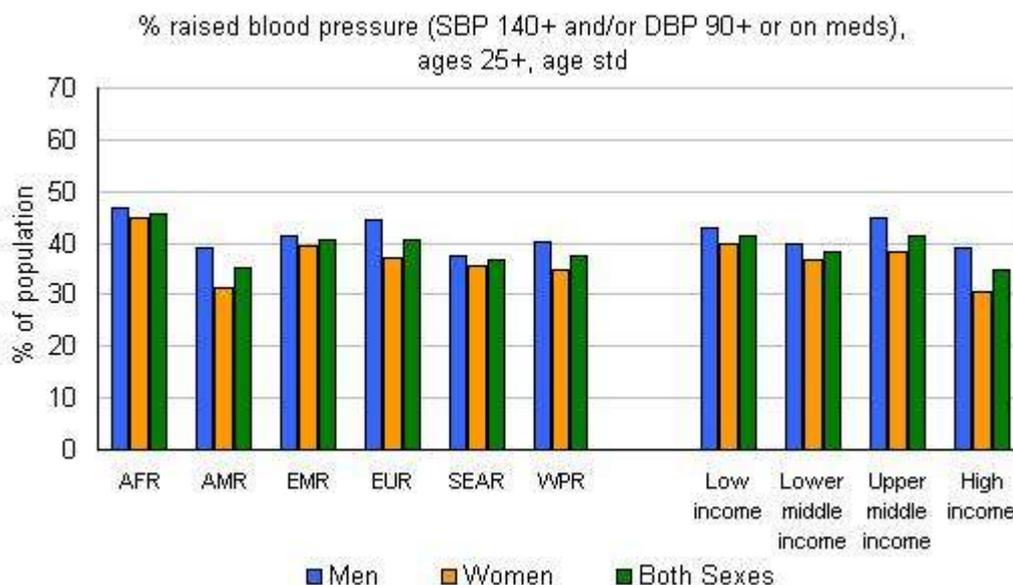


Fig. 1: WHO situation and trends of hypertension [4]

Age distribution of hypertension

There is a progressive increase in HTN with increasing age. Age-related HTN has been found to be predominantly systolic than diastolic. SBP rises to the 8th or 9th decade, whereas DBP either remains constants or is seen to decline at 40 years of age. The National Health and Nutrition Examination Survey (NHANES) [5] reported HTN to grow significantly with increase in age across all sexes and race groups. In terms of age specific prevalence, 3.3% of white men aged 18-29

years had HTN, this increased to 13.2% in men aged 30-39 years. This further increased to 22% in men 40-49 years, 37.5 % in men 50-59 years, and 51% in men aged 60-74 years [5].

Distribution of hypertension by gender

NHANES III reported 34%, 25% and 23.3% for men and 31%, 21% and 21.6% for women among blacks, whites and Mexican Americans respectively. The prevalence of HTN reported by NHANES was 12%

for white men and about 5% for women between the ages 14-49 years. However, age-related blood pressure rise for women exceeded that of men. A prevalence of 55% for white women and 50% for white men aged 70 years and above was reported [5].

Distribution of hypertension by race or ethnicity

Black people have been shown to have higher incidence and prevalence of HTN when compared to white people. HTN prevalence has been reported a 50% increase in blacks than white. Many studies in the US and UK reported not only high prevalence but also low awareness of HTN in blacks than in whites [5, 6].

The incidence and prevalence of HTN in Mexican Americans were seen to be similar or lower than those in non-Hispanic Americans. NHANES III reported 20.6% age-adjusted prevalence of HTN in Mexican-Americans and 23.3% in non-Hispanic Americans. The understanding of the renin-angiotensin system (RAS) may be required to understanding ethnic influence. There is suppression in renin secretion when the kidney detects increased amounts of sodium excretion. Black people predominantly develop HTN even at an early age and have lower renin activity [5].

Risk Factors for hypertension

Modifiable risk factors of hypertension include

Too much sodium (salt) in the diet: Salt and hypertension are not good combination. The salt used in cooking is sodium chloride and has affinity to attract water to itself. This leads to additional burden on the human heart to pump extra volume of blood

Obesity: being overweight or obese exerts extra pressure making it work harder and also under difficult conditions.

Excessive alcohol consumption: there is association between alcohol consumption and high blood pressure. This has been scientifically established, particularly the excessive intake of alcohol. Alcohol intake in moderation is acceptable.

Smoking: Smoking increases blood pressure temporarily and consequently increases the heart rate, but prolonged smoking cause hypertension.

Unhealthy diet: diets high in cholesterol, saturated fat, trans fat, sweets, red meats, sugared beverages but low in fruits, vegetables, whole grains and nuts have been observed to increase blood pressure

Stress: Loss of control over situations influences stress. Stress and high blood pressure are significantly associated and have deleterious effects.

Diabetes: People with diabetes are more likely to develop elevated blood pressure, this is partly because of the effect of diabetes on the endothelium of the blood vessels, which is particularly so for the arteries. Diabetes can make the arteries less pliable and elastic, which can lead to endothelial dysfunction, there for increasing workload for the heart to pump blood more forcefully around the body

Physical inactivity: lack or inadequate physical activity is a risk factor of hypertension

Non-modifiable risk factors include:

Age: the chances of developing raised blood pressure increases with age.

Race: African Americans have a higher risk of developing HTN. HTN is most common in the black race worldwide, particularly in Africa. The reasons for this is not clearly defined, but has been suggested to be may related to environmental stressors, genetics and increased salt intake.

Family History: People with positive family history have a higher risk. If either or both of parents have high blood pressure, there is increased risk of you developing HTN.

Gender: Men have hypertension at earlier age than women, and they have higher risk of developing complications than women, until the age of 60. However, after the age of 60, more women have hypertension than men.

Prognosis of hypertension

Majority of individuals diagnosed with HTN will have increasing blood pressure (BP) with increase in age. Untreated hypertension is notorious for increasing the risk of mortality and is time and again described as a silent killer. Mild to moderate HTN, when left untreated, could be cause 30% of atherosclerotic disease risk and 50% of organ damage in people within 8-10 years after onset [7].

Biomarkers in diagnosis and progression of hypertension

A study carried out [7] studied 9 biomarkers of HTN at baseline: C-reactive protein (inflammation), fibrinogen (thrombosis and inflammation), aldosterone, plasminogen activator inhibitor-1 (fibrinolytic potential), B-type natriuretic peptide and N-terminal proatrial peptide (neurohormonal activity), renin, urinary albumin/creatinine ratio (glomerular endothelial) and homocysteine (renal function and oxidative stress). Incidence of HTN was defined as 140/90mmHg [7]. Three out of nine biomarkers were significantly associated with incidence of HTN. They included C-reactive protein (1.26; 95% CI: 1.05-1.51), urinary

albumin/creatinine ratio (1.21; 95% CI: 1.02-1.43) and plasminogen activator inhibitor (1.28; 95% CI: 1.05-1.57). The incidence of HTN was 4.5, 9.9 and 6.4 per 100 person years for participants 0, 1 and 2 elevated biomarkers respectively. The threshold for prediction of HTN was associated with high specificity (0.92) but low sensitivity (0.15) for 2 elevated biomarkers. Biomarkers of inflammation, low-grade albuminuria and reduced fibrinolytic potential were jointly associated with HTN incidence.

Prevention and Control Strategies of Hypertension

With hypertension being of public health concern, its prevention is of great importance. Epidemiological principles for control and prevention include primary prevention, secondary prevention and tertiary prevention of HTN.

Primary prevention of hypertension

Health promotion/ education

HTN prevention can be achieved by the complementary application of strategies targeted at the general population and also at individual as well as at high risk groups for HTN. Interventions which include lifestyle modifications are more likely to be successful and the complete reduction of risk are also likely to be greater when targeted at persons of older age and those who are at higher risks when compared to their counterparts who are younger or at decreased risk [8].

Population based strategy

For any comprehensive plan to prevent hypertension, a population-based approach aimed at decreasing blood pressure is imperative. A rather small decrease in the distribution of SBP is more likely to result in a substantial decrease in HTN, HTN-related disease burden [9]. In an analysis on the basis of the Framingham Heart Study experience, it was concluded by [10] that a 2 mmHg decrease in a population of DBP 35 to 64 years, would result in a 17% reduction in HTN prevalence, a 6% decrease in CHD risk and a 14% decrease in transient ischemic attacks and stroke risk [11].

Public health interventions and approaches which include the lowering of sodium or caloric density in food, attractive, safe and convenient environment provided for exercise are ideal population based strategies for a decline in blood pressure in communities. For improved physical activity, it is important to enhance behavior to change models and access to facilities which include parks, bike paths and walking trails [12].

Intensive targeted strategy

Intensive targeted approaches that are aimed at reducing blood pressure in people most at risk should be implemented to complement community-based

approaches discussed in the previous chapter for HTN prevention.

Groups of people at high risk include persons with family history of HTN, persons that have a high-normal BP, overweight or obese, take excess sodium or insufficient potassium in diet, persons who consume excess amounts of alcohol and those who are prone to sedentary lifestyles [12].

Prevention strategies targeting risk factors

Weight loss

The clinical guidelines for the identification, evaluation and treatment of overweight and obesity in Adults provides supportive evidence of modest reduction in body weight [13].

A study by [14] reported experiences of 181 normotensives who participated in a trial of HTN prevention. Those who were assigned to the 18 months of intervention had reduced body weight by 3.5 kg and their SBP reduced by 5.8 mmHg while their DBP reduced by 3.2 mmHg. After a period of 7 years, the incidence of HTN was 18.9% in the intervention group and 40.5% in the control group. These finding apparently suggests weight loss as an effective intervention in decreasing HTN incidence. Another study reported a 21% decrease in incidence of HTN in the intervention group where participants in the intervention group 4.4 kg and a reduction in SBP of 5.0 mmHg and DBP of 7 mmHg [15].

Reduction in dietary sodium

Several Meta analyses have established the efficacy of decreased sodium intake in lowering of blood pressure [16, 17, 18]. It was found that sodium reduction significantly associated with SBP reduction in normotensives. A randomized control trial (RCT) according to [16] estimated an average reduction of about 77 mmol/d in dietary sodium intake resulted in a 1.9 mmHg decrease in SBP (95% CI, 1.2-2.6 mmHg) and a 1.1mmHg decrease in DBP (95% CI, 0.6-1.6 mmHg). Another RCT trial which focused on the Dietary Approaches to Stop Hypertension (DASH) observed that a decrease from a high level sodium intake (mean urinary sodium excretion, 142 mmol/d) to an intermediary level (mean urinary sodium excretion, 107 mmol/d) caused a reduction in SBP by 1.3 mmHg (P=0.03) during consumption of the DASH diet which was very high in vegetables, fruits and low-fat dairy products and 2.1 mmHg (P<0.001) during a consumption of a usual American control diet [19].

Physical activity increase

A meta-analysis carried out by [12] reported experiences of 1,108 normotensives which enrolled in 27 RCT. It was reported that there was a 4.04 mmHg (95% CI, 2.75-5.32) decline in SBP in those who were

assigned to the aerobic exercise group when compared to the control group. The degree of the effectiveness of the intervention was however reported to be independent of the intensity of the exercise program. The surgeon report of physical activity and health recommends persons to exercise at least 30 minutes on most if not on all days of the week [20]. The WHO has also recommended 30 minutes exercise daily as a strategy to regulate body weight, blood pressure, blood lipid levels, blood glucose levels etc. Doing >150 minutes of moderate physical activity or an hour of vigorous physical activity every week will reduce the risk of coronary heart disease by about 30%.

WHO recommendations of physical activity for adults aged 16-64 years [21].

Adults aged 18–64 should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity.

Aerobic activity should be performed in bouts of at least 10 minutes duration.

For additional health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity.

Muscle-strengthening activities should be done involving major muscle groups on 2 or more days a week.

Alcohol consumption moderation

A study carried out by [22] reported that reduced alcohol consumption (median decline in self-reported alcohol consumption was 76%, a range from

16% to 100%) was significantly associated with decreased blood pressure. It was also reported that the observed relationship between reduction in mean percentage of alcohol intake and decrease in blood pressure was dose-dependent. Another RCT found a decreased consumption of alcohol was significantly associated with a 3.56 mmHg (95% CI, 2.51-4.61) reduced level of SBP and 1.8 mmHg (95% CI, 0.58-3.03) reduced level of DBP. It is therefore recommended that consumption of alcohol be limited to only 1 oz (30 mL) ethanol, 10 oz (300 mL) wine, 24 oz (720 mL) beer or 2 oz (60 mL) 100-proof whiskey a day for men and not more than 0.5 oz (15 mL) ethanol a day for women and lighter weight persons [8].

Potassium supplementation

A meta-analysis and clinical trial indicate lowering of blood pressure in both normotensives and hypertensive by potassium supplementation [16]. Reported decreased SBP by 1.8 mmHg (95% CI, 0.6-2.9) and DBP by 1.0 mmHg (95% CI, 0.0-2.1) due to potassium supplementation (median 75 mmol/d).

Whole diets modification

Several dietary interventions in the DASH-sodium and DASH trials have incorporated nutritional recommendations for the decrease in blood pressure[19, 23]. An 8 weeks DASH trial which randomized participants with SBP less than 160 mmHg and DBP between 80 to 95 mmHg into 3 arms; group one (low fruits, vegetables, dairy products high in fat), group two (a similar diet but richer in fruits and vegetables) and group 3 (a DASH diet rich in vegetables, fruits and low-fat dairy products). Among the normotensive participants with blood pressure <140/90 mmHg, the DASH diet decrease their SBP by 3.5 mmHg (p<0.001). Another study using the DASH-sodium diet, normotensives which were given the DASH diet and also low level urinary sodium excretion of 67 mmol/d reduced their SBP by 7.1 mmHg. A significant decrease in DBP was also observed [19].

Table 1: Lifestyle modifications for primary prevention of HTN [8]

| Lifestyle Modifications for Primary Prevention of Hypertension |
|--|
| 1. Engage in regular aerobic physical activity such as brisk walking (at least 30 minutes per day, most days of the week). |
| 2. Maintain normal body weight for adults (body mass index 18.5 – 24.9 kg/m ²). |
| 3. Limit alcohol consumption to no more than 1 oz (30 mL) ethanol (e.g., 24 oz [720 mL] of beer, 10 oz [300 mL] of wine, or 2 oz [60 mL] 100-proof whiskey) per day in most men and to no more than 0.5 oz (15 mL) of ethanol per day in women and lighter weight persons. |
| 4. Reduce dietary sodium intake to no more than 100 mmol per day (approximately 2.4 g of sodium or 6 g of sodium chloride). |
| 5. Maintain adequate intake of dietary potassium (more than 90 mmol [3,500 mg] per day). |
| 6. Consume a diet that is rich in fruits and vegetables and in low-fat dairy products with a reduced content of saturated and total fat (Dietary Approaches to Stop Hypertension [DASH] eating plan). |

Secondary prevention

Secondary prevention includes screening for disease progression and taking preventative measures in order to limit further complications[24]. Secondary prevention of HTN occurs when your blood pressure is within prehypertension limits (120-139 systolic / 80-89 diastolic).

Preventative measures

- Assessment of other risk factors
- Maintain a healthy body weight through diet and exercise
- Avoid smoking or excessive alcohol consumption
- Actively participate in learning about health promoting activities in school and the community
- Obtain weekly blood pressure readings to monitor progression
- Screen for comorbidities including: diabetes, hyperlipidemia, obesity
- Early treatment to prevent worsening of disease
- Medication training/ skill building
- Life style modifications

An evidence-based approach according to [25], which employed a three stage program that included a. case finding and management among clinic attendees, b. work-site screening in industries and in the service sector, with referral to the usual primary care providers and c. community-oriented primary care. Secondary prevention of hypertension involved routine blood pressure measurements of attendees of regular primary care clinics, this enabled them recognize hypertensive and consequently manage and follow-up unidentified hypertensive as well as study risk factors associated with hypertension. Each clinic had a list of defined persons eligible for care. This approach was based on a cost-effectiveness model constructed among the US system of care which suggested that adequate control of identified hypertensive was more cost-effective than extensive screening. This was to augment and complement the clinic case finding of stage one as it was intended to detect and also refer hypertensive cases who rarely use their primary care clinics located in their neighborhood and to encourage therapeutic adherence in others. This approach was found to be crucial for maintenance of adequate control, irrespective of whether treatment was administered at the work-site or at the referral clinics [25].

Lifestyle modifications

JNC 7 recommendations to lower BP and decrease cardiovascular disease risk include the following, with greater results achieved when 2 or more lifestyle modifications are combined [8]:

- Weight loss (range of approximate systolic BP reduction [SBP], 5-20 mm Hg per 10 kg)
- Limit alcohol intake to no more than 1 oz (30 mL) of ethanol per day for men or 0.5 oz (15 mL) of ethanol per day for women and people of lighter weight (range of approximate SBP reduction, 2-4 mm Hg)
- Reduce sodium intake to no more than 100 mmol/day (2.4 g sodium or 6 g sodium chloride; range of approximate SBP reduction, 2-8 mm Hg)
- Maintain adequate intake of dietary potassium (approximately 90 mmol/day)
- Maintain adequate intake of dietary calcium and magnesium for general health
- Stop smoking and reduce intake of dietary saturated fat and cholesterol for overall cardiovascular health
- Engage in aerobic exercise at least 30 minutes daily for most days (range of approximate SBP reduction, 4-9 mm Hg)

Tertiary prevention

Tertiary prevention occurs after a disease state is present requiring focused measures to return the body to a pre-disease state maximizing adequate functioning. All risk factors must be addressed in order to limit impairment and minimize damage to the body. Tertiary prevention of HTN occurs when blood pressure is ≥ 140 mmHg for SBP or DBP is ≥ 90 mmHg.

Required actions -

- Seek guidance from a medical professional
- Obtain daily/weekly blood pressure readings for monitoring disease progression
- Treatment of comorbidities including: diabetes, hyperlipidemia, obesity
- Pharmacological interventions aimed at lowering blood pressure
- Care
- Life style modifications (refer to table 1)

Pharmacologic therapy

If lifestyle modifications are insufficient to achieve the goal BP, there are several drug options for treating and managing hypertension. Thiazide diuretics are the preferred agents in the absence of compelling indications [26].

Compelling indications may include high-risk conditions such as heart failure, ischemic heart disease, chronic kidney disease, and recurrent stroke, or those conditions commonly associated with hypertension, including diabetes and high coronary disease risk. Drug intolerance or contraindications may also be factors [26]. An angiotensin-converting enzyme (ACE)

inhibitor, angiotensin receptor blocker (ARB), calcium channel blocker (CCB), and beta-blocker are all acceptable alternative agents in such compelling cases.

The following are drug class recommendations for compelling indications based on various clinical trials:

- Heart failure: Diuretic, beta-blocker, ACE inhibitor, ARB, aldosterone antagonist
- Postmyocardial infarction: Beta-blocker, ACE inhibitor, aldosterone antagonist
- High coronary disease risk: Diuretic, beta-blocker, ACE inhibitor, CCB
- Diabetes: Diuretic, beta-blocker, ACE inhibitor, ARB, CCB
- Chronic kidney disease: ACE inhibitor, ARB
- Recurrent stroke prevention: Diuretic, ACE inhibitor

CONCLUSION

Many contemporary studies have suggested risk factors modification and behavioral change particularly in diet modification, increase physical activity, smoking cessation and decrease in alcohol consumption as prevention and control strategies of hypertension. Other studies have suggested combined drug treatment with lifestyle modification as more effective control strategies of hypertension. Primary prevention of hypertension is key as studies have demonstrated how healthy lifestyles play a crucial role in the prevention of the development and progression of high blood pressure. It is for this reason, health care providers and policy makers should champion the course of lifestyle modification and behavioral change particularly targeted at high risk individuals.

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