Ethnic Variations in Blood Pressure and Hypertension

The Netherlands Organisation for Health Research and Development financially supported the studies described in this thesis.

Financial support by the Department of Health Policy and Management, Erasmus Medical Centre, for the publication of this thesis is gratefully acknowledged.

Ethnic Variations in Blood Pressure and Hypertension/
Charles Agyemang

Thesis Erasmus MC, University Medical Center Rotterdam – With- ref

ISBN 90-8559-107-4

Printed by Optima Grafische Communicatie, Rotterdam

Ethnic Variations in Blood Pressure and Hypertension

Etnische verschillen in bloeddruk en hypertensie

Thesis

to obtain the degree of Doctor from the
Erasmus University Rotterdam
by command of the
rector magnificus

Prof.dr. S.W.J. Lamberts

and in accordance with the decision of the Doctorate Board

The public defence shall be held on

Thursday 8 December 2005 at 11.00 hrs

by

Charles Okyere Agyemang
born at Kumasi, Ghana

Doctoral Committee

Promotors:

Prof.dr. M. Berg

Prof. RS. Bhopal

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'Science and art belong to the whole world, and before them vanish the barriers of nationality'. (Goethe)

To: Ank

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List of abbreviations

ABP	Ambulatory blood pressure
ABPM	Ambulatory blood pressure monitoring
ACEI	Angiotensin-converting enzyme inhibitors
ALLHAT	Antihypertensive & Lipids-Lowering Treatment to Prevent Heart Attach Trial
ARB	Angiotensin II Receptor Blockers
BB	ßeta-Blockers
BMI	Body mass index
BP	Blood Pressure
CCB	Calcium channel blockers
CDC	The Centers for Disease Control and Prevention
CHD	Coronary Heart Disease
CI	Confidence interval
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
ICSHB	The International Collaborative Study on Hypertension in Blacks
ISH	International Society of Hypertension
NHBPEP	National High Blood Pressure Education Program
OR	Odd ratio
SBP	Systolic blood pressure
SRR	Standard risk ratios
WCE	White-coat effect
WHO	World Health Organisation
WHR	Waist-hip-ratio
WMD	Weighted mean differences

General Introduction

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Introduction

High blood pressure (BP) or hypertension is an important public health burden in all populations of the world. Recent 'Global Burden of Hypertension' data showed that more than a quarter of the world's adult population (nearly one billion) had hypertension in 2000 and this is projected to increase by about 60% (1.56 billion) in 2025.[1] Hypertension is one of the leading causes of cardiovascular disease (CVD) and premature mortality and the lifetime risk of developing the condition exceeds 50% for most populations.[2,3] The World Health Report 2002 estimates that 7 million premature deaths are attributable to hypertension.[4] The disability and mortality caused by hypertension-related damage sustained by the kidneys, brain, and heart, are the factors that make hypertension such a serious public health burden.[5] Given the association between hypertension and damage to these vital organs, control of high BP clearly ranks as one of the most important concerns of the public, as well as of health care professions.

There are stark ethnic group differences in the experiences of hypertension and its related sequelae such as coronary heart disease (CHD), stroke and other manifestations of cardiovascular disease (CVD).[6-8] The evidence from the United States has consistently shown that hypertension is more common, more severe, develops at an earlier age, and leads to more clinical sequelae in African Americans as compared with White Americans.[9] The excess risk experienced by African Americans is among the most fundamental observations on the distribution of BP in human populations.[10] The reasons for the excess risks experienced by African Americans still remained an epidemiological puzzle despite extensive research and widespread debate and speculations.[11] This gap of knowledge, and the consistent high prevalence of hypertension among some African descent populations have led to some suggestions that hypertension is a 'disease' of people of African descent, and yet the earlier report showed lower mean BP with little or no rise with age, and low prevalence of hypertension among ancestral African populations living traditional lives.[12] The recent report from South Africa also showed a lower BP levels and prevalence of hypertension among South African Black people compared with South African White people.[13] Within sub-Saharan/ Africa itself, there are substantial variations in BP and prevalence of hypertension between and within countries with the emerging data consistently showing increasing prevalence rates across the continent.[14-17] At the same time the emerging data in sub-Saharan/African countries also show that hypertension awareness, treatment and control - which are central to prevention - are unacceptably low.[14-15]

In Europe, over the past few decades the populations belonging to ethnic minority groups have increased. Furthermore, these populations are now ageing and the burden of chronic disease is becoming an important one. Understanding the pattern of disease among these groups may also help in understanding the mechanisms underlying the rapid onset of a cardiovascular epidemic in developing countries. However, in Europe, BP and hypertension data among ethnic minority groups are very scarce although there is widespread acceptance that in people of African and South Asian descent populations, BP levels and prevalence of hypertension are higher compared with their European White counterparts. Studies in Europe on ethnic differences in BP and prevalence of hypertension have, however, not always shown consistent results with, for example, Cruickshank et al[18] finding no difference in Birmingham in the UK. It is unclear whether BP and prevalence of hypertension differ between ethnic groups in Europe. It is also unclear whether hypertension management and control - which are central to prevention – differ between ethnic groups in Europe.

In children, BP tracking patterns in the United States have confirmed that persistent BP elevation may be related to hypertension in adulthood,[19] and that there appears to be ethnic variations in BP trajectories.[20] The emerging evidence also suggests that primary hypertension is detectable and occurs commonly in the young.[21] In addition, the presence of elevated BP in childhood has been linked with left ventricular hypertrophy.[22] Despite these findings, BP data on ethnic minority children are very scanty. In Europe, for example, it is unclear whether BP levels vary among children from different ethnic groups. It is also unclear whether ethnic differences in BP in adult populations are reflected in children. It is important to examine cardiovascular risk factors in children so that appropriate interventions can be introduced early in life before unhealthy lifestyles become firmly established.

As hypertensive diseases, CHD and stroke are among the dominant causes of death in ethnic minority groups with rates even higher than in the European origin White populations,[6-8] hypertension needs to be carefully managed among these groups.

Aims and outline of thesis

The main objectives of this thesis were:

i. To assess and provide epidemiological data on BP and hypertension among different ethnic groups in both adult and children with prime focus on European, African and South Asian descent populations
ii. To provide epidemiological data on hypertension management and control among different ethnic groups, and to identify opportunities for appropriate prevention.

Chapters 2 to 4 present the results of systematic literature reviews conducted to establish current knowledge on BP levels and prevalence of hypertension among different ethnic groups. Chapter 5 presents results of a meta-analysis on ethnic differences in white-coat effect. Chapter 6 shows the results of a meta-analysis on nocturnal BP fall patterns among various ethnic groups. Chapter 7 describes the results of ethnic differences in hypertension, awareness, treatment and control among Dutch ethnic groups in South-east Amsterdam. Chapter 8 describes factors associated with hypertension awareness, treatment and control among the adult population in a sub-Saharan African setting (Ghana, West Africa), and chapter 10 presents the results of BP profiles among Ghanaian children and compares these BP values with those of the United States children to determine how BP levels may be changing over time.

A note on terminology relating to race and ethnicity

Research on ethnicity and health has a scientific potential in determining the causes of disease, explaining the interaction between cultural factors and health, and ensuring that services and policies provide equitable access to health care. However, the paradoxes behind many of the ethnic and racial differences in health are not easily explained, and better definitions and terminology, and greater attention to population heterogeneity, are a prerequisite for scientific progress.[23]

Both race and ethnicity are difficult concepts.[23] Whilst there is a conceptual distinction between race and ethnicity, these terms are often used interchangeably or as synonyms. The traditional scientific concept of race refers to biological homogeneity as defined by a few phenotypical features.[24] However, the bulk of genetic differences (90 to 95 percent) occur within populations, and not between continental groupings,[25] and the genes responsible for different physical characteristics that underpin race are few and rarely relate to either behaviour or disease.[26-28] Current consensus is that race has relatively little scientific value but that it is an important political and psychosocial concept.[29]

Ethnicity is a multi-dimensional concept, which is being used frequently in medical research.[23,30] It is neither simple nor consistent. It comprises one or more of the following: shared origins or social background; shared culture or tradition that is distinctive, maintained between generations, and leads to a sense of identity and group; and a common language or religious tradition.[23] The characteristics that define ethnicity are, however, not fixed and may change over time, which makes ethnicity difficult to measure and utilise in research.[23,31] The concept of ethnicity encapsulates cultural, behavioural and environmental factors that increase the risk of disease, hence it is crucial in epidemiology and public health. In Europe, race is being abandoned in favour of ethnicity.[29,32] The United States is moving to the compound phrase race/ethnicity.[33]

There is no consensus on appropriate terms for the scientific study of health by ethnicity, and published guidelines are yet to be widely adopted. We have followed general conventions used in the UK and the Netherlands, whenever appropriate, the terminology used in the original documents were referred to. The term South Asian refers to populations originating from the Indian Sub-continent, effectively, India, Pakistan, Bangladesh and Sri Lanka. White is the term currently used to describe people with European ancestral origins. Black refers to people with African ancestral origin. The term African Caribbean /Afro-Caribbean when used in Europe and North America usually refers to people, with African ancestral origin that migrated via the Caribbean islands**.** The term African American refers to a person of African ancestral origins who self identifies or is identified by others as African American. The term Creole when used in the Netherlands usually refers to people, with African ancestral origin that migrated via Surinam. The term Hindustani when used in the Netherlands usually refers to people, with South Asian ancestral origin that migrated via Surinam. Ethnic minority groups refer to minority non-European non-white populations.

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Is the blood pressure of South Asian adults in the UK higher or lower than that in European white adults? A review of cross-sectional data

Charles Agyemang[1]

Raj Bhopal[2]

[1]**Institute of Health Policy and Management, Erasmus Medical Centre, Rotterdam, The Netherlands**

[2]**Public Health Sciences, University of Edinburgh College of Medicine and Veterinary Medicine, Teviot Place, Edinburgh, UK**

Published in *J Human Hypertension* 2002; **16**:739-51

Modified version: *Hypertension and coronary heart disease in South Asians* **In**: Patel KCR & Bhopal RS [First Edition] The Epidemic of Coronary Heart Disease in South Asian Populations: Causes and Consequences: Chapter 10 pp110-120; The South Asian Health Foundation (U.K.): UK

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Abstract

The objective of the study was to review published evidence on whether blood pressure levels and the prevalence of hypertension are higher or lower in South Asian adults living in the UK as compared to white populations. A systematic literature review was carried out using MEDLINE 1966-2001, EMBASE 1980-2001, and citations from references. A total of 12 studies were identified. The data showed important differences between studies in terms of age and sex of samples, definition of South Asians (Indian, Pakistani and Bangladeshi) and methods of evaluating blood pressure. Seven studies reported lower mean systolic blood pressures, while seven studies showed higher diastolic pressures in South Asian men compared to white men. In women, six of nine studies showed lower systolic blood pressures, while five reported higher diastolic pressures. For prevalence of hypertension, five of 10 studies reported higher rates in South Asian men than in white men. Two of six studies showed higher prevalence rates in South Asian women. Overall, the most representative sample and up-to-date data came from the Health Survey of England 1999. Both blood pressure and the prevalence data show important differences between South Asian subgroups, yet most studies combined them. The data also showed a geographical variation between London (comparatively high blood pressure in South Asians) and the rest of the UK (comparatively low or similar blood pressure). Bangladeshis had low blood pressure and body mass index (BMI). In other South Asian subgroups, low blood pressure and the low BMI did not always coincide. To conclude, the common perception that blood pressure in South Asians is comparatively high is unreliable - the picture is complex. Overall, blood pressures are similar but there is stark heterogeneity in the South Asian groups, with slightly higher blood pressure in Indians, slightly lower blood pressure in Pakistanis, and much lower blood pressure in Bangladeshis. Variations in study methods, body shape, size and fat, and in the mix of South Asian groups probably explain much of the inconsistency in the results.

Keywords: Ethnic variations; South Asians; blood pressure; prevalence of hypertension

Introduction

Coronary heart disease and stroke are dominant causes of death in South Asian populations in the UK, and the rates are even higher than in the white population. As a major cardiovascular risk factor, hypertension needs to be carefully managed in South Asian populations. There is a perception that, in South Asians, BP levels are comparatively high. Studies in the UK on differences between South Asian and white populations in BP and prevalence of hypertension have, however, given inconsistent conclusions.[1] These inconsistencies prompted us to undertake this review.

Methods

Search strategy

EMBASE and MEDLINE searches identified the papers published from 1980 to 2001 and 1966 to 2001, respectively. Medical Subject Heading (MeSH) 'Asians', 'South Asians', 'Indians', 'Pakistanis', 'Bangladeshis' or 'ethnic minority population' was combined with BP and hypertension. The search was limited to the United Kingdom and papers published in the English language only. We included studies that reported BP and/or prevalence data on samples of South Asian adults in the community in comparison with a white or general population. All studies based on clinically selected patients and on children were excluded. The reference list of all known primary studies and review articles was scrutinised and additional relevant citations were identified. Totally, 12 studies were examined.[3,4,5,6,7,8,9,10,11,12,13,14] One author[10] supplied unpublished data.

Study selection and data extraction

Of the 12 papers included in the final analysis, 11 were cross-sectional surveys, most in community settings but some in occupational settings. Whitty *et al*[12] reported cross-sectional data from a cohort design. One study was designed specifically to focus on BP levels and prevalence of hypertension,[3] the rest had broad aims. As given in the paper, 95% confidence intervals and *P*-values are reported. Mean systolic and diastolic BP of the total study sample in one study was calculated as the results were based on age-specific groups.[3]

Results

Methods of the reviewed studies

Table 1 shows that most reports relate to the 1980s and 1990s and that 11 of the 12 studies were carried out in England, six in and around London.[5,6,7,10,12] Four study[4,5,6,10] samples were based on general practices lists. Two studies[3,8] were factory based, two were from the health surveys for England,[13,14] one was based on postcode sectors,[9] one was based on office staff,[12] one was based on a health authority register used for a health and lifestyle survey,[11] and one was general practice and factory based.[7] Most studies had broad aims relating to a range of cardiovascular risk factors. Name analysis,[7,8,9,10,11] self-reported origin,[3,6,8,11,13,14] country of birth,[5,6,7] and parental origin[6,11] were the usual indicators of ethnicity. The age range varied widely. Most studies assessed BP levels and prevalence of hypertension in men and women separately, but a few only studied men.[3,5,8] Response rates varied widely from 60[14] to 83.4%.[8] The largest, most representative and most up-to-date study was the Health Survey for England 1999.[14]

Mean blood pressure levels

Table 2 shows that BP was measured in three studies in hospital clinics,[4,10,11] one study in a health center,[6] four studies in participants' own homes,[5,9,13,14] one study in a work place and hospital clinic,[7] and three studies in a workspace.[3,8,12] In six studies, participants' BP were measured with a random zero sphygmomanometer.[3,4,5,6,7,9] Bhopal *et al*[11] used mercury sphygmomanometers, Knight *et al*[8] electronic (Copal) sphygmomanometers, Cappuccio *et al*[10] automated ultrasound sphygmomanometers, whereas Primatesta *et al*[13] and Karlsen *et al*[14] Dinamap 8100 monitors. Most studies measured BP in a sitting position. Two studies measured participants' BP in a supine position.[5,10] The readings reported varied. For instance, three studies measured BP twice and used the mean systolic and diastolic of the two readings,[5,11,12] three studies[10,13,14] measured BP thrice and used the average of the last two readings, whereas in other studies either the first[3] or the second[8] reading was taken for the final analysis. Two studies[5,9] published actual mean systolic and diastolic BP, one study published age-adjusted median systolic and diastolic BP,[7] and the rest of the studies published age-adjusted mean systolic and diastolic BP.[3,4,6,8,9,10,11,12,13,14]

In seven of 12 studies, mean systolic BP was lower in South Asian men than in white men.[3,4,8,9,11,12,14] In four studies, systolic BP was higher in South Asian men than in white men.[5,6,7,10] In the Primatesta *et al*[13] study, South Asian men aged 16-39 years had lower systolic BP than white men, and those aged 40 years and above had higher pressure than white men. Seven of 12 studies showed higher mean diastolic BP levels in South Asians compared to whites.[3,5,7,9,10,12,13] Two studies reported lower mean diastolic BP in South Asians than in whites[4,11] and one study reported the same levels.[6] In Karlsen *et al*,[14] the age-standardised ratio of mean diastolic BP was higher in Indian men but lower in Pakistani and Bangladeshi men than in the general population. In Bhopal *et al*,[11] Pakistani and Bangladeshi men had much lower BP than Indians. Four studies[3,8,11,14] that had a representative sample of the adult population reported either lower or same BP levels in South Asian men compared to white men.

Nine studies reported on women.[4,6,7,9,11,11,12,13,14] In six of nine studies, the mean systolic BP was lower in South Asian women than in white women.[4,6,9,11,12,13] Two studies reported higher mean systolic BP in South Asians than in whites.[7,10] In Karlsen *et al*,[14] the age-standardised ratio of mean systolic BP was lower in Bangladeshis and Indians but higher in Pakistanis compared to the general population.[7,9,10,12,13] For diastolic BP, five studies reported higher levels in South Asians than in whites, and three studies reported lower levels in South Asians than in whites.[4,6,11]

Prevalence of hypertension

Table 3 shows 10 studies that reported on the prevalence of hypertension using various cut off points.[3,5,6,8,9,10,11,12,13,14] Most of the studies that assessed the prevalence of hypertension reported on a cut off point of systolic BP of 160 mmHg or more and/or diastolic BP of 95 mmHg or more, and defining as hypertensive those receiving hypertension treatment. [4,5,6,9,10,11,12] Karlsen *et al*[14] reported on a cut off point of systolic pressure of 140 mmHg and/or diastolic pressure of 90 mmHg. Knight *et al*[8] used systolic pressure of 160 mmHg and/or diastolic pressure of 90 mmHg as a criterion. With two exceptions,[5,9] where it was unnecessary because of age matching, all studies standardised their prevalence rates for age. In five of 10 studies, prevalence rates were higher in South Asian men than in white men.[5,6,8,9,10] Two studies reported lower prevalence rates in South Asian men than in white men.[3,11] In Primatesta *et al*,[13] the prevalence rate was lower in the 16 to 39-year group but higher in the 40 and above year group compared to the white population. In the Karlsen *et al* study, the observed prevalence of hypertension was lower in South Asian groups than in white groups. However, after adjusting for the effects of age and presenting data in the form of relative risk ratios (comparing each subgroup to the overall general population), the age-standardised risk ratios were lower in Bangladeshi and Pakistani men and higher in Indian men than in white men.[14] Six studies reported on women.[6,9,10,11,13,14] Of these, two reported higher prevalence rates in South Asians,[10,11] one reported the same rates,[9] and two reported lower rates in South Asian women[6,13] compared to white women. Bhopal *et al*[11] found the prevalence in Bangladeshi women to be much lower than in Europeans. In the Karlsen *et al* study, the observed prevalence rates were lower in South Asian groups. However, after the effects of age have been controlled for, the age-standardised risk ratios were higher in Pakistani and Indian women but lower in Bangladeshi women compared to white women.[14] One study result was based on men and women combined and reported higher rates in South Asian populations than in white population.[12] Sex differences were not taken into account.

Regional variations

Table 4 shows that in four of six studies in London,[5,6,7,10] mean systolic BP was higher in South Asian men than in white men. Also, four of six studies[5,7,10,12] reported higher diastolic BP in South Asian men than in white men. Four of six studies[5,6,10,12] reported on prevalence rates in London. Of these, three studies[5,6,10] reported higher prevalence rates in South Asian men. By contrast, all the four studies[3,8,9,11] in cities outside London reported lower mean systolic BP in South Asian men than in white men.

Five studies[4,6,7,10,12] in London included women. Of these, three studies[4,6,12] reported lower and two studies[7,10] reported higher mean systolic BP in South Asian women than in white women. For diastolic BP, three studies[7,10,12] reported higher and two studies[4,6] reported lower levels in South Asian women compared to white women. Both studies[9,11] in cities outside London reported lower systolic BP in South Asian women than in white women.

Anthropometry data and mean difference in blood pressure

Table 5 shows, in studies ranked by South Asian sample size, body mass index (BMI), waist-to-hip ratio (WHR) and mean difference in systolic and diastolic BP. The Health Survey for England 1999[14] and Bhopal *et al*[11] provided data on several South Asian subgroups. Totally, 10 studies reported on BMI[4,5,6,7,8,9,10,11,13,14] in men. With one exception in which BMI was higher in Indian and Pakistanis,[11] all studies reported lower BMI in South Asian men. Six studies reported on WHRs,[6,7,9,10,11,14] and all reported higher levels in South Asian men except the Williams *et al* study[9] in which the level was lower in South Asian men. In contrast to South Asian men, six of eight studies on women[6,7,9,10,11,13,14] reported higher levels in South Asian women compared to whites, the exceptions being Bangladeshis in Karlsen *et al*[14] and McKeigue *et al*[4] in which BMI was lower. Six studies reported on WHRs and all reported higher values in South Asian women.[6,7,9,10,11,14] The mean difference in systolic and diastolic BP varied widely. The mean systolic difference was particularly marked in Bangladeshi men and women, being 10.3-17.0 mmHg lower compared to whites. These patterns of BP were partly associated with BMI, the fit being better in men than in women. For example, Karlsen *et al*[14] reported lower BMI and lower BP in South Asian men. In women, the BMI was higher in Indian and Pakistani women but BP was lower.

Table 1 Contextual details – publication, location, timing, sampling frame, design, aims, sample identification and size and response rate

First author surname & date of publication	a. b. c. d.	Place Time of study Study design Sampling frame	Aim	Indicator of ethnicity	Age group studied	Sample size by ethnic group	Response rate
Cruickshank et al, 1983 [3]	a. b. c. d.	Birmingham, England Not given Cross-sectional survey Twelve factories	Factory based health survey to assess ethnic differences in blood pressures.	Assigned by observers based on confirmation of ethnic origin and appearance.	16-64	Whites 439 Asians172 (Women not studied)	78%
McKeigue et al, 1988 [4]	a. b. c. d.	Northwest London, England. June 1985-April 1986 Cross-sectional survey Five general practice lists	To investigate whether the increases in coronary heart disease in immigrants from the Indian subcontinent in Britain can be explained by other risk factors	Country of origin.	35-69	Non-Asians 132 Men 90 women 42 Bangladeshis 121 Men 76 women 45	66%
Miller et al, 1988 [5]	a. b. c. d.	Northwest London, England Not given. Cross-sectional survey. General practice list	To determine dietary and other characteristics relevant for coronary heart disease in men of Indian, West Indian and European descent in London.	Country of birth and ethnic origin.	45-54	Europeans 68 Indians 75 (Women not studied)	81%
Cruickshank et al, 1991 [6]	a. b. c. d.	Northwest London, England. Not given. Cross-sectional survey. Two general practice list	To investigate the mechanisms leading to ethnic differences in plasma C-peptide and insulin in relation to glucose tolerance and blood pressure.	Reported grandparental origin and place of birth.	45-74	Whites 101 Men 49 women 52 Gujerati Indians107 Men 47 women 60	77%
McKeigue et al, 1991 [7]	a. b. c. d.	London, England. June 1988-July 1990. Cross-sectional survey. Four factories & 16 general practice list.	To test the relationship of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risks in South Asians.	By name, country of birth, and appearance.	40-69	Europeans 1761 Men 1515 women 246 South Asians 1712 Men 1421women 291	62% for South Asians & 66% for non-Asians
Knight et al, 1992 [8]	a. b. c. d.	Bradford, England. Not given. Cross-sectional survey. Two textile factories	To examine the hypothesis that insulin resistance associated with centralised adiposity is the mechanism underlying the predisposition of Asian immigrant communities to both ischaemic heart disease and diabetes mellitus.	By name and self reported origin.	20-65	Non-Asians 156 Asians 110 (Women not studied)	83.4% for Asians & 70.6% for non-Asians

Table 1 continued

First author surname & date of publication	a. Place, b. Time of study c. Study design d. Sampling frame	Aim	Indicator of ethnicity	Age group studied	Sample size by ethnic group	Response rate
Williams et al, 1993 [9]	a. Glasgow, Scotland. b. 1987. c. Cross-sectional survey. d. Electoral register & postcode sectors	To compare common health experiences of the South Asian population with that of the general population.	By name analysis, with ethnicity verified at interview.	30-40 for South Asians & 35 for Gen. population	Gen. Population 319 Men 141 women 178 South Asians 159 Men 75 women 84	81%
Cappuccio et al, 1998 [10]	a. London, England. b. March 1994- July 1996. c. Cross-sectional survey. d. Nine general practice lists.	Population based survey to assess prevalence of cardiovascular risk factors in different ethnic groups.	Parental origin, name analysis, verified at interview.	40-59	Whites 523 Men 233 women 290 South Asians 503 Men 253 women 250	64%
Bhopal et al, 1999 [11]	a. Newcastle upon Tyne. b. April 1993-October 1994 for Europeans and May 1995-March 1997 for South Asians. c. Cross-sectional survey. d. Family health services authority register.	To compare coronary risk factors and disease prevalence.	Name analysis, confirmed by, self-report and grandparents place of birth.	25-74	Europeans 824 Men 425 women 399 South Asians 684 Indians 259 Men 105 women 154 Pakistanis 305 Men 156 women 149 Bangladeshis 120 Men 64 women 56	67.5% for South Asians and 64.2% for Europeans
Whitty et al, 1999 [12]	a. Whitehall, London, England. b. Not given. c. Cohort study but cross-sectional analysis d. Civil servants	To compare differences in biological risk factors for cardiovascular disease between three ethnic groups in the Whitehall II study.	Assigned by an observer at interview.	35-56	White 8973 Men 6159 women 2814 South Asians 577 Men 357 women 220	73%
Primatesta et al, 2000 [13]	a. England. b. 1991-1996. c. Cross-sectional survey. d. Selected postcode sectors	General health survey for England.	Self-reported at interview.	16 -39 and 40 and above	Whites 52525 Men 24516 women 28009 South Asians 1443 Men 720 Women 723	Not given
Karlsen et al, 2001 [14]	a. England. b. 1999. c. Cross-sectional survey. d. Selected postcode sectors.	General health survey for England.	Self reported based on ethnic origin.	16 and above	Gen. Population 11884 Men 5401 Women 6483 Indians 819 Men 401 women 418 Pakistanis 680 Men 319 women 361 Bangladeshi 472 Men 214 women 258	60% for ethnic minorities

TABLE 2 Setting, measurement technique and mean systolic and diastolic pressures by sex and ethnic group

First author surname and date of publication	Setting of measurement	a. Sphygmomanometer b. Position c. Reading taken for analysis	Indicator of measurement	Blood pressure levels by sex and ethnic group				
				Ethnic group	Men SBP	Men DBP	Women SBP	Women DBP
Cruickshank et al, 1983 [3]	Workplace	a. Hawksley random zero b. Sitting c. First reading.	Age stratified mean SBP and DBP.	Whites Asian origin	134.2* 128.7	78.7 79.9*	Not studied	Not studied
McKeigue et al, 1988 [4]	Hospital clinic	a. Hawksley random zero b. Sitting c. Not given	Age adjusted mean SBP and DBP.	Non-Asians Bangladeshi	129*** 119	81 78	123* 113	78 75
Miller et al, 1988 [5]	Home	a. Hawksley random zero b. Supine c. Average of the two readings	Mean SBP and DBP.	European Indian	138.0 141.5	86.1 88.4	Not studied	Not studied
Cruickshank et al, 1991 [6]	Health centre	a. Hawksley random zero b. Sitting c. Not given	Age adjusted mean SBP and DBP.	White Gujerati Indian	129 ± 20 137 ± 20	77 ± 14 77 ± 13	128 ± 18 123 ± 25	75 ± 12 66 ± 14
McKeigue et al,1991 [7]	Workplace and Hospital clinic	a. Hawksley random zero b. Not given c. Not given.	Age adjusted median SBP and DBP.	European South Asian	121 (121-122) 126 (124-127)	78 (77-78) 82 (81-82)	120 (118-122) 126 (123-129)	76(75-77) 77(76-79)
Knight et al, 1992 [8]	Workplace	a. Electronic (Copal), UK b. Sitting c. Second readings	Mean SBP and DBP.	Non-Asian Asian	137.4(134-139.9) ** 131.4 (128-134.8)	79.6(78.0, 81.2) 79.5 (77.5, 81.6)	Not studied	Not studied
Williams et al, 1993 [9]	Home	a. Hawksley random zero b. Sitting, c. Nearest even number	Mean SBP and DBP.	Gen. Population South Asian	124.5 123.8	80.3 86.3**	115.3 111.3	74.0 74.5
Cappuccio et al, 1998 [10]	Hospital clinic	a. Automated ultrasound b. Supine c. Average of last 2 readings.	Age adjusted mean SBP and DBP.	White South Asian	127.9 (125.5-130.3) 131.0(128.7-133.3)**	82.1(80.7, 83.4) 85.4(84.1, 86.7)***	123.5(121.5, 125.6) 127.9(125.7, 130.1)**	77.2(76.2-78.3) 79.8(78.6-81.0)***
Bhopal et al, 1999 [11]	Hospital clinic	a. Mercury b. Sitting c. Average of the two readings.	Age adjusted mean SBP and DBP.	Europeans South Asians Subgroups: Indians Pakistanis Bangladeshis	129.1*** 119.2 123.9 119.0 112.1	78.1** 70.6 72.1 70.9 67.5	121.2*** 117.7 122.6 115.7 108.8	68.8 67.9 68.4 68.0 66.4

Table 2 continued

First author surname and date of publication	Setting of measurement	a. Sphygmomanometer b. Position and c. Reading taken for analysis	Indicator of measurement	Blood pressure levels by sex and ethnic group Ethnic group	Men SBP	SRM	Men DBP	SRM	Women SBP	SRM	Women DBP
Whitty et al, 1999 [12]	Workplace	a. Not given b. Not given c. Average of the two readings.	Age adjusted mean SBP and DBP.	Whites	123.4**		76.8		120.0		75.0
				South Asians	121.4		77.4		119.5		75.4
Primastesta et al, 2000 [13]	Home	a. Dinamap 8100 monitor b. Sitting c. Average of the last two readings.	Age adjusted mean SBP and DBP.	Whites							
				16-39	132.2**		70.3		122.8**		68.1
				40 and above	141.6		81.5		138.0		75.8
				South Asians							
				16-39	129.5		71.9		118.9		67.2
				40 and above	143.5		84.1***		137.9		77.1
Karlsen et al, 2001 [14]	Home	a. Dinamap 8100 monitor b. Sitting c. Average of the last two readings.	Age adjusted mean SBP and DBP.			SRM		SRM		SRM	Not given but no significant difference between the groups
				Gen. population	136.8	1	76.2	1	132.5	1	
				Indian	134.0	1.0	77.7	1.03	126.2	0.99	
				Pakistani	129.7	0.98	72.5	0.99	122.9	1.02	
				Bangladeshi	126.5	0.94	72.9	0.99	120.2	0.97	

ABREVIATIONS

BP = Blood Pressure, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, P = P value, Values in parentheses are 95% confidence intervals,
*p<0.05, ** p<0.01, *** p<0.001, comparing ethnic groups, SRM = Standard ratios of means

Discussion

Key findings

Most studies reported lower mean systolic but higher diastolic BP in South Asians in both men and women compared to whites. For prevalence of hypertension, most studies reported higher rates in South Asian men compared to white men. Prevalence rates in South Asian and white women showed inconclusive results. Both mean BP and the prevalence of hypertension data show important differences between South Asian subgroups,[11,14] yet most studies combined them as one homogeneous group. The data also shows a geographical variation between the London area (comparatively high blood pressure in South Asian men) and the rest of the UK (comparatively low or similar BP). While the lower BP in Bangladeshis was associated with lower BMI, differences in obesity clearly did not account for much of the ethnic variation.

Three studies[15,16,17] on adults, which were excluded from this review because they were based on clinically selected patients study, reported lower BP levels in the South Asian population than in the white population.

Limitations of the review

The results are not clear-cut. The inconsistent results in the UK studies could be explained by the different mixes of Indians, Pakistanis and Bangladeshis in the sample and variations in methods used in different studies. These differences mean that between-study differences are not reliable and focus attention on within-study variations. The importance of heterogeneity among South Asian groups has long been emphasised but generally ignored.[18] Variations in South Asian subgroups are important especially in the context of cardiovascular diseases; risk factor profiles and disease outcomes differ too.[11] Heterogeneity among the UK ethnic groups study populations may be a general explanation for these inconsistent results from BP and prevalence of hypertension studies.

Four studies had the most representative samples of the South Asian groups,[9,11,13,14] the rest of the studies were based on specific locations such as general practitioner lists,[4,5,6,7,10] factories,[3,8] a combination of general practitioner lists and factories,[7] or civil servants.[12] These studies based on specific locations have potential problems of sample bias. For example, using a general practitioner list means that South Asians who were not registered were excluded.

Huge variations in methods of measurement of BP limit the capacity to synthesise the data. For example, in six studies, participants' BPs were measured with a Hawksley random zero sphygmomanometer.[3,4,5,6,7,9] In other studies,[13,14] a Dinamap 8100 monitor was used, which tends to provide higher systolic and lower diastolic BP levels than mercury sphygmomanometer readings.[19,20] Participants' BPs were measured in different locations. The readings analysed also varied. The estimated white coat hypertension ranges from 12 to 53% depending upon the population studied and definition used.[21,22] It is difficult to account for the effect of white coat hypertension in each study. It is also not clear whether the effect of white coat hypertension differs in different ethnic groups. Differences in BMIs, age and sex further complicate interpretation of the findings of these studies.

Some studies[5,6,7] used country of birth as an indicator of ethnicity. This implies that many Indians, Pakistanis and Bangladeshis who were born in the UK were excluded.

Huge variations in study methods make it problematic for researchers to conduct a meta-analysis, which would require collecting the original data. It is a delicate judgement on whether such a task is feasible and worthwhile.

Discussion of the key results

The Newcastle Heart Project study and the 1999 Health Survey for England are the two studies that paid particular attention to the heterogeneity of the South Asian populations in the UK.[11,14] The Newcastle study found major differences among South Asian subgroups. Bangladeshi men and women had lower mean systolic and diastolic BP than Indian and Pakistani men. Prevalence of hypertension was less common in Bangladeshis in both men and women than in Indian and Pakistani groups.[11] In the recent Health Survey for England 1999, similar findings emerged. Bangladeshi men and women had lower age-standardised mean systolic and diastolic BP and a lower prevalence of hypertension than their Indian and Pakistani counterparts.[14] These two studies emphasise the importance of studying South Asian subgroups separately rather than combining them as one homogeneous group, which may make other studies misleading. For example, the McKeigue *et al*[7] study classified South Asian subgroups on the basis of language and religion. This study found significantly higher systolic BP in Sikh (128 mmHg, N=731) and Punjabi Hindus (128 mmHg, N=159) than in Muslims (120 mmHg N=211) and Gujarati Hindus (122 mmHg, N=127). Despite these differences, they were combined as one group.

Table 3 Criteria for diagnosis, age adjustment and prevalence of hypertension by sex and ethnic group

First author surname and date of publication	Criteria for diagnosis of hypertension and location of measurement	Age adjustment	Ethnic groups	Prevalence by sex and ethnic groups: Men	Women
Cruickshank et al, 1983[3]	BP≥ 160/95 mm Hg or below these values if receiving antihypertensives, Workplace.	Yes	Whites Asian origin	22% 17%	Not studied
Miller et al, 1988[5]	BP≥ 160/95 mm Hg or receiving anti-hypertensives therapy, Hospital.		Europeans Indians	21% 40%	Not studied
Cruickshank et al, 1991[6]	BP≥ 160/95 mm Hg or below these values if receiving anti-hypertensives, Health centre.	Yes	Whites Gujerati Indians	20% 32%	34% 13%
Knight et al, 1992[8]	BP≥ 160/90 mm Hg, Workplace.	Yes	Non-Asian Asians	23.1% 26.6%*	Not studied
Williams et al, 1993[9]	BP≥ 160/95 mm Hg, Home.		Gen. population South Asians	14% 22%	5% 5%
Cappuccio et al, 1998[10]	(WHO) criteria: BP≥ 160/95 mm Hg or on drug therapy and (JNC) criteria: BP ≥ 140/90 mm Hg or on drug therapy, Hospital clinic.	Yes	Whites: WHO criteria JNC criteria South Asians: WHO criteria JNC criteria	18% 33% 28% 44%	13% 24% 26% 36%
Bhopal et al, 1999[11]	BP ≥ 160/95 mm Hg or reported hypertension, Hospital clinic.	Yes	Europeans South Asians Subgroups: Indians Pakistanis Bangladeshis	18% 10% 14% 9% 6%	12% 14% 15% 12% 5%
Whitty et al, 1999[12]	BP≥ 160/95 mm Hg or below these values if receiving anti-hypertensives, Workplace.	Yes	White South Asians	OR 1 OR 2.3 (95% CI 1.6-3.3) (Combined)	
Primatesta et al, 2000[13]	BP≥ 160/95 mm Hg or below these values if receiving anti-hypertensives, Home.	Yes	Whites: 16-39 40 and above South Asians: 16-39 40 and above	 4% 36% 3% 51%***	 2% 35% 2% 33%
Karlsen et al, 2001[14]	BP≥ 140/90 mm Hg and all those receiving anti-hypertensives, Home.	Yes, as SRR not as prevalence	 Gen. population Indian Pakistani Bangladeshi	SRR 40.8% 1 35.7% 1.03 25.5% 0.89 23.6% 0.74	SRR 32.9% 1 23.6% 1.12 16.1% 1.25 12.3% 0.89

BP = Blood Pressure, OR = Odd Ratio, SRR = Standardised risk ratio, *p<0.5, **p<0.01, ***p<0.001, comparing ethnic groups

Table 4 Summary of evidence comparing blood pressure in community samples in South Asian and white/European origin populations:

First author by place	Location of measurement	Mean Systolic BP Men	Mean Systolic BP Women	Mean diastolic BP Men	Mean diastolic BP Woman	Prevalence Men	Prevalence Women
London							
McKeigue et al, 1988 [4]	Hospital clinic	W***	W*	W	W	Not given	Not given
Miller et al, 1988 [5]	Hospital clinic	SA†	Not studied	SA	Not studied	SA	Not studied
Cruickshank et al, 1991[6]	Health Centre	SA†	W†	Same	W†	SA†	W†
McKeigue et al, 1991[7]	Workplace and Hospital clinic	SA†	SA†	SA†	SA†	Not given	Not given
Cappuccio et al, 1998 [10]	Hospital clinic	SA**	SA***	SA***	SA***	SA†	SA†
Whitty et al, 1999[12]	Workplace	W**	W	SA	SA	(SA)**** Combined	
Cities outside London							
Cruickshank et al, 1983[3]	Workplace	W*	Not studied	SA*	Not studied	W	Not studied
Knight et al, 1992[8]	Workplace	W**	Not studied	Same	Not studied	SA*	Not studied
Williams et al, 1993[9]	Home	W	W	SA**	SA	SA	Same
Bhopal et al, 1999[11]	Hospital clinic	W***	W***	W**	W	W	SA(I)
Whole of England							
Primatesta et al, 2000[13] 16-39 yrs	Home	W**	W**	SA	W	W	Same
Primatesta et al, 2000[13] 40+ yrs	Home	SA	W	SA***	SA	SA***	W
Karlsen et al, 2001[14]	Home	W	P*	I	Not given	I	I,P*

*p<0.05, **p<0.01, ***p<0.001,****p<0.0001, comparing ethnic groups. † no statistical analysis.
SA means BP is higher in South Asians; W means BP is higher in white/Europeans; P means BP is higher in Pakistanis; and I means BP is higher in Indians.

TABLE 5 Mean body mass index (BMI), waist-hip ratio (WHR) and mean difference in blood pressures by sex and ethnic group ordered by ranking on size of the South Asian sample

First author surname & date of publication	Ethnic group. (No)	Anthropometry data				Mean difference			
		Men		Women		Men		Women	
		BMI	WHR	BMI	WHR	SBP	DBP	SBP	DBP
Karlsen *et al,* 2001[14]	 Gen. Population (11,884) Indian (819) Pakistani (680) Bangladeshi (472)	SRR 1 0.66 0.74 0.32	SRR 1 1.48 1.54 1.33	SSR 1 1.02 1.61 0.63	SRR 1 1.73 2.79 1.33	 -2.8 -7.1 -10.3	 1.5 -3.7 -3.3	 -6.3 -9.6 -12.3	Not given but no difference between the groups
McKeigue *et al,*1991[7]	Europeans (1,761) South Asians (1,712)	25.9 25.7	0.94 0.98	25.2 27.0	0.76 0.85	 5.0	 4.0	 6.0	 1.0
Primastesta *et al*, 2000[13]	Whites (52,525) 16-39 (20,9060 40 and above (31619) South Asians (1443) 16-39 (914) 40 and above (529)	% Obesity 10% 18%** 8% 12%	Not given	 12% 21% 13% 23%	Not given	 -2.7 1.9	 1.6 2.6	 -3.9 -0.1	 -0.9 4.0
Bhopal *et al,* 1999[11]	Europeans (824) South Asians (684) Subgroups: Indians (259) Pakistanis (305) Bangladeshis (120)	26.1 26.4** 26.9 26.6 25.4	0.91 0.97 0.96 0.96 0.97	26.0 27.6 27.9 27.8 26.3	0.79 0.89** 0.85 0.88 0.88	 -9.9 -5.2 -10.1 -17.0	 -7.5 -6.0 -7.2 -10.6	 -3.5 1.4 -5.5 -12.4	 -0.9 -0.4 -0.8 -2.0
Whitty *et al,* 1999[12]	Whites (8973) South Asians 577	Not given	Not given	Not given	Not given	 -0.2	 0.6	 -0.5	 0.4
Cappuccio *et al,* 1998[10]	Whites 523 South Asians 503	25.8*** 24.8	0.922 0.944***	26.1 27.1***	0.798 0.848***	 3.1	 3.3	 4.4	 2.6
Cruickshank *et al*, 1983[3]	Whites 330 Asian origin 167	Overall not given	Overall not given	Not studied	Not studied	 -5.5	 1.2	Not studied	Not studied
Williams *et al,* 1993[9]	Gen. Population 381 South Asians 159	25.3 25.4	0.95 0.94	24.8 27.0*	0.82 0.84**	 -0.7	 6.0	 -4.0	 0.5
McKeigue *et al*, 1988[4]	Non-Asians 132 Bangladeshi 121	26.6*** 23.9	Not given	26.1*** 23.7	Not given	 -10.0	 -3.0	 -10.0	 -3.0
Knight *et al,* 1992[8]	Non-Asians 156 Asians 110	25.0** 23.8	Not given	Not studied	Not studied	 6.0	 0.1	Not studied	Not studied
Cruickshank *et al,*1991[6]	Whites 101 Gujerati Indians 107	26.2 25.2	0.914 0.946	26.3 26.8	0.835 0.888	 8.0	 0.0	 -5.0	 9.0
Miller *et al,* 1988[5]	Europeans 68 Indians 75	26.6 25.0	Not given	Not studied	Not studied	 3.5	 2.3	Not studied	Not studied

SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, *p<0.05, ** p<0.01, *** p<0.001, comparing ethnic groups, SRR = Standard risk ratios of means

Higher BP levels reported in the London area, as opposed to other cities outside London, may reflect different environmental risk factors experienced by ethnic groups living in different parts of the UK or perhaps, more likely, a different population mix. Current evidence[11,14] shows that BP levels are higher in people of Indian origin than of Pakistani and Bangladeshi origins. It is possible that London studies which reported higher BP levels in South Asians might have consisted mainly of Indians. For example, the Cruickshank *et al*[6] and McKeigue *et al*[7] studies reported higher BP levels in South Asian groups. The McKeigue *et al* study drew a large part of the South Asian sample from 16 general practices in the London borough of Ealing. This borough is composed of 16.1% of Indians (many of them Sikh Punjabis).[23] Also, in the Cruickshank *et al*[7] study, the South Asian subjects were mainly Gujarati Indians. By contrast, the McKeigue *et al*[4] study in the London borough of Tower Hamlet, with a predominantly Bangladeshi population,[23] reported BP levels that were lower compared to white populations.

The studies that have a representative sample of the adult population reported lower or similar BP levels in South Asian men compared to white men.[3,8,11,13,14] By contrast, most studies on older adults reported higher BP[5,6,7,10,13] and higher prevalence rates[5,6,10,13] in South Asian men than in white men. The Primatesta *et al*[12] study had a representative sample of both younger and older adult populations. The older South Asian men group had a higher BP and a higher prevalence rate, but the younger South Asian men group had a lower mean systolic BP and lower prevalence rate than white men.[12] This may reflect higher BP and higher prevalence rates in the older South Asian men only, but not in the South Asian population as a whole.

A higher prevalence of hypertension was not always associated with higher BP in that population. For example, the Miller *et al*[5] study reported a marked excess of hypertension in Indian men, but average BP levels were similar in all ethnic groups. Again, in the Knight *et al*[8] study, the prevalence of hypertension was higher in Asian than non-Asian men, but systolic BP was higher in non-Asians. The possible explanation for this is that either the percentage on antihypertensive treatment differs or the distribution of BP is skewed. In the Miller *et al*[5] study, a larger number of Indians were on antihypertensive therapy compared to whites (P<0.05).

A lower mean systolic BP but a higher mean diastolic BP reported in South Asians in both men and women implies lower pulse pressure. Evidence on pulse pressure as a marker of cardiovascular risk is well established, especially coronary heart disease.[24,25] This finding of lower pulse pressure in this review is in direct contrast with the evidence of higher coronary events in South Asian populations, particularly in Bangladeshis.[26] A meta-analysis of nine major prospective observation studies has shown an important association between increased BP and stroke and coronary heart disease.[27] There are some problems in extrapolating these data to all ethnic groups, as it is unknown whether the physiological optimal level of BP is the same in each group.[28] For example, it remains uncertain whether for a given level of BP, South Asian populations will have a higher risk of death than white people. Findings from the St James Study in Trinidad showed that the attributable mortality after 8 years from a systolic BP between 155 and 179 mmHg was 12.3 for Indian and 8.2 European men, and above 180 mmHg it was 22.8 and 15.1 deaths/1000 person years, respectively.[29] Bangladeshis have a lower mean systolic and diastolic BP than Indians and Pakistanis,[11,14] but a higher mortality from stroke than their Indian and Pakistani counterparts.[26] These differences may be a result of an interaction between risk factors. Among South Asian subgroups, it may be that for a given level of BP the Bangladeshis will have a higher risk of death than Indians or Pakistanis. These findings seem to suggest that the reporting of BP and distributions is better than using arbitrary cutoff points.

In conclusion, BP levels and prevalence of hypertension differ across groups. Some of the inconsistent results in the UK studies could be explained by the variations in methods of measurement of BP and classifications of ethnic minority groups. Differences in age, sex and BMI also potentially confound findings. A growing proportion of people of Indian, Pakistani and Bangladeshi origin are UK born. There is therefore a strong case for epidemiological research among younger groups to examine BP levels and prevalence of hypertension and how this pattern may be changing. Future research must recognize the various subgroups of South Asians and should be designed in such a way that data can be combined easily for future systematic reviews, e.g., by standardising the way in which BP is measured.

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Is the blood pressure of people from African origin adults in the UK higher or lower than that in European origin white people? A review of cross-sectional data

Charles Agyemang,[1]

Raj Bhopal[2]

[1]Institute of Health Policy and Management, Erasmus Medical Centre, Rotterdam, The Netherlands

[2]Public Health Sciences, University of Edinburgh College of Medicine and Veterinary Medicine, Teviot Place, Edinburgh, UK

Published in *Journal of Human Hypertension* 2003; **17**:523-534

3

Abstract

The aim of the study was to review published evidence on whether blood pressure (BP) levels and the prevalence of hypertension are higher in adult populations of African descent living in the UK as compared to the white population. A systematic literature review was carried out using MEDLINE 1966-2002 and EMBASE 1980-2002 and citations from references. In all, 14 studies were identified. Nearly all studies were carried out in the London area. The data showed important differences between studies in terms of age and sex of samples, definition of African/black and methods of evaluating BP. A total of 10 studies reported higher mean systolic BPs, while 11 studies reported higher mean diastolic BPs in men from African descent compared to white men. In women, 10 of 12 studies reported higher systolic, and 10 of 12 studies reported higher diastolic BPs. For prevalence of hypertension, eight of 10 studies reported higher rates in men from African descent; eight of nine studies showed higher rates of hypertension in women from African descent. Overall, the most representative sample and up-to-date data came from the Health Survey for England '99. Ethnic group differences in BP were not present in the younger age groups. Women of African descent had higher BP and higher body mass index (BMI). In men of African descent high BP did not coincide with higher BMI. In conclusion, the reported higher rates of hypertension in people from African descent in the UK are confirmatory of the USA African-American and white comparisons. Variations in study methods, size and body composition, and in the mix of Afro-Caribbean and West African groups explain much of the inconsistent results in the UK studies.

Keywords: ethnic variations; African descent; blood pressure; race; hypertension

Introduction

Hypertensive diseases and stroke are among the dominant causes of death in people from African descent in the UK with rates even higher than in the European origin white population (henceforth White). As a major cardiovascular risk factor, hypertension needs to be carefully managed in UK's African origin populations. There is widespread acceptance that in people from African descent blood pressure (BP) levels are comparatively high. Studies in the UK on differences between people from African descent and white populations in BP and prevalence of hypertension have, however, not always shown consistent results with, for example, Cruickshank *et al*[1] finding no difference in Birmingham. Such inconsistency prompted us to undertake this research study. We apply the concept of ethnicity as discussed by Senior and Bhopal,[2] and given in the glossary.

Methods

Search strategy

EMBASE and MEDLINE were used to identify papers published from 1980-2002 and 1966-2002, respectively. Medical Subject Heading 'African Caribbean', or 'West Africans', or 'blacks', or 'ethnic minority population' were combined with BP and hypertension. The search was limited to the United Kingdom and papers published in the English language only. We included population-based studies that reported BP and/or prevalence data on people from African descent in comparison with a white or general population. All studies based on clinically selected patients and children were excluded. The reference list of all known primary studies and review articles were scrutinised and additional relevant citations were identified. In all, 14 studies were found that were relevant.[3,4,5,6,7,8,9,10,11,12,13,14,15,16] Two authors supplied unpublished data.[11,15]

Study selection and data extraction

Of 14 papers included in the final analysis, 11 were cross-sectional surveys, most in the community, but some in occupational settings. Lane *et al*'s[16] study includes some of the research participants in the study of Cruickshank *et al*.[5] Meade *et al*'s[3] was a cohort study and Whitty *et al*[12] reported cross-sectional data from a cohort design. Confidence intervals of 95%, *P*-values and odd ratios are reported as given in the paper. Mean systolic and diastolic BPs of the total study sample in two studies were calculated as the results were based on age-specific groups.[5,15]

Results

Methods of the reviewed studies

Table 1 shows that most reports relate to the 1970s to 1990s and all studies were carried out in England. With five exceptions,[5,13,14,15,16] two of which were in Birmingham, one in Manchester, and two national surveys,[13,14] all studies were carried out in and around London. Six studies[6,7,8,10,11,15] were based on general practices' lists, three studies[3,4,5] were factory based, two studies were from the population-based health surveys for England,[13,14] and one study was based on civil servants.[12] Two studies had samples from different sources.[9,16] Three studies[5,10,16] were designed specifically to compare BP levels; the rest had broad aims relating to a range of cardiovascular risk factors. Name analysis,[9,11] self-reported origin,[9,13,14] country of birth,[3,6,7,9] parental origin,[8,10,11,15] and observer classification[5,12,16] were used as indicators of ethnicity. One study did not state which indicator of ethnicity was used.[4] The age range varied widely. In one study, the Afro-Caribbean group was significantly older than their white counterparts ($P<0.0001$).[16] Most studies assessed BP levels and prevalence of hypertension in men and women separately, but two only studied men.[7,9] Response rates varied widely, ranging from 58%[10] to 81%.[7] Sample size varied widely. The largest, most representative and most up-to-date study was the Health Survey for England '99.[14]

Blood Pressure levels

Table 2 shows that BPs were measured in three studies in a workplace,[3,4,5] in three studies at the participants' own homes,[7,13,14] in four studies in a health centre,[6,8,10,15] in one study in a hospital clinic[11] and in one study in a hospital clinic and in a workplace.[9] In six studies, BP was measured with a random zero sphygmomanometer.[5,6,7,8,9,16] Sever *et al*[4] used a Bosomat automatic BP recorder, Cappuccio *et al*[11] used an automated ultrasound sphygmomanometer, whereas Primastesta *et al*[13] and Karlsen *et al*[14] used a Dinamap 8100 monitor. Most studies measured BPs in a sitting position. Two studies measured participants' BP in a supine position.[7,11] The readings reported varied. For instance, some studies measured BP twice and used the mean readings for analysis.[6,8,10,12,16] In another three studies, BPs were measured thrice and the averages of the last two readings were taken for analysis,[11,13,14,15] whereas in some studies either the first[5] or the lowest of the three[4] readings were taken for analysis. Two studies did not indicate which measurements were taken for analysis.[3,9] Two studies reported actual mean systolic and diastolic BPs,[3,4] two age-adjusted median systolic and diastolic BPs[9,10] and the rest of the studies published age-adjusted mean systolic and diastolic BPs.[5,8,11,12,13,14,15,16]

Table 1 Contextual details – publication, location, timing, design, sampling frame, aims, sample identification and size and response rate

First author surname & date of publication	a. Place b. Time of study c. Study design d. Basis of Sample	Aim	Indicator of ethnicity	Age group studied	Sample size by ethnic group	Response rate
Meade et al, 1978[3]	a. Northwest London. b. Not given. c. Prospective study. d. Factory.	To compare variables associated with ischaemic heart disease in ethnic groups working at the production site of a food processing company in north-west London.	Place of birth.	18-49	Whites 412 Men 351 women 61 Blacks 141 Men 86 women 55	Not given
Sever et al, 1979[4]	a. Northwest London b. Not given. c. Cross-sectional survey. d. Factory.	To compare ethnic differences in blood pressure with observations on nor-adrenaline and renin.	Not given.	24-58	Whites 62 Men 37 women 25 Blacks 53 Men 35 women 18	65%
Cruickshank et al, 1983[5]	a. Birmingham. b. Not given. c. Cross-sectional survey. d. Twelve factories.	Factory based health survey to assess ethnic differences in blood pressures.	Assigned by observers based on confirmation of ethnic origin and appearance.	16-64	Whites 603 Men 439 women 164 Blacks 274 Men 173 women 101	78%
Haines et al, 1987[6]	a. Northwest London. b. 1983-1986. c. Cross-sectional survey. d. General practice list.	To compare blood pressure, smoking, alcohol consumption and obesity between whites and blacks of Caribbean origin.	Country of origin.	17-70	Whites 936 Men 486 women 450 Blacks 415 Men 191 women 224	61%
Miller et al, 1988[7]	a. Northwest London. b. Not given. c. Cross-sectional survey. d. General practice list.	To determine dietary and other characteristics relevant for coronary heart disease in men of Indian, West Indian and European descent in London.	Country of birth and ethnic origin.	45-54	Europeans 68 West Indians 24 (Women not studied)	81%
Cruickshank et al, 1991[8]	a. Northwest London. b. Not given. c. Cross-sectional survey. d. Two general practice lists.	To investigate the mechanisms leading to ethnic differences in plasma C-peptide and insulin in relation to glucose tolerance and blood pressure.	Reported grandparental origin.	45-74	Whites 101 Men 49 women 52 Afro-Caribbeans 106 Men 53 women 53	77%
McKeigue et al, 1991[9]	a. London. b. June 1988-July 1990. c. Cross-sectional survey. d. Four factories & 16 general practice lists.	To test the relationship of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risks in South Asians.	By name, country of birth, and appearance.	40-69	Europeans 1515 Afro-Caribbeans 209 (Women not studied)	66%

Table 1 continued

First author surname & date of publication	a. Place b. Time of study c. Study design d. Basis of sample	Aim	Indicator of ethnicity	Age group studied	Sample size by ethnic group	Response rate
Chaturvedi et al, 1993[10]	a. London. b. Not given. c. Cross-sectional survey. d. Six general practice lists.	To determine the prevalence of hypertension in UK Afro-Caribbeans and to test the hypothesis that diurnal BP patterns may differ in Afro-Caribbeans and Europeans.	Appearance and parental origin.	40-64	Europeans 585 Men 272 women 313 Afro-Caribbeans 581 Men 247 women 334	58%
Cappuccio et al, 1998[11]	a. London. b. March 1994- July 1996. c. Cross-sectional survey. d. Nine general practice lists.	Population based survey to assess prevalence of cardiovascular risk factors in different ethnic groups.	Parental origin, name analysis, verified at interview.	40-59	Whites 523 Men 233 women 290 African origin 549 Men 208 women 341	64%
Whitty et al, 1999[12]	a. Whitehall, London. b. Not given. c. Cohort study but cross-sectional analysis. d. Civil Service.	To compare differences in biological risk factors for cardiovascular disease between three ethnic groups in the Whitehall II study.	Assigned by an observer at interview.	35-56	Whites 8973 Men 6159 women 2814 Afro-Caribbeans 360 Men 141 women 219	73%
Primatesta et al, 2000[13]	a. England. b. 1991-1996. c. Cross-sectional survey. d. Selected postcode sectors.	General Health Survey for England.	Self-reported in interview.	16 -39 and 40 and above	Whites 52525 Men 24516 women 28009 Blacks 811 Men 351 women 460	Not given
Karlsen et al, 2001[14]	a. England. b. 1999. c. Cross-sectional survey. d. Selected postcode sectors.	General Health Survey for England.	Self reported based on ethnic origin.	16 and above	Gen. Population 11884 Men 5401 women 6483 Afro-Caribbeans 719 Men 287 women 432	60% for ethnic minorities
Cruickshank et al, 2001[15]	a. Manchester. b. Not given. c. Cross-sectional survey. d. Population registers of 4 inner city health centres.	To assess the public health burden from high blood pressure and the current status of its detection and management in four African-origin populations.	Grandparental origin.	25-74	European 558 Men 265 women 293 African-Caribbean 480 Men 222 women 258	60-98%
Lane et al, 2002[16]*	a. Birmingham & West Midlands. b. 1979-1986 & 1996-1997. c. Cohort. d. 12 factories, INTERSALT study & 4 churches.	To examine the prevalence of hypertension and mean blood pressures among Afro-Caribbeans and South-Asians in England compared with Caucasians.	Assigned by observers based on confirmation of ethnic origin and appearance.	Mean age 42.9 for Caucasian and 45.2 for Afro-Caribbean	Caucasians 2169 Men 1534 women 635 Afro-Caribbean 453 Men 273 women 180	Not given

*Lane et al's study[16] includes some of the research participants in the study of Cruickshank et al[5].

TABLE 2 Setting, measurement technique and mean systolic and diastolic blood pressures by sex and ethnic group

First author surname and date of publication	Setting	a. Sphygmomanometer b. Position c. Reading taken for analysis	Measurement reported	Blood pressure levels by sex and ethnic group Ethnic group	Men SBP	Men DBP	Women SBP	Women DBP
Meade et al, 1978[3]	Workplace.	a. Not given. b. Not given. c. Not given.	Mean systolic and diastolic BP	White Day Shift Night Shift Black Day Shift Night shift	 125.6 134.9 133.4** 139.3	 75.5 82.2 81.5** 87.3	 119.1 Not studied 125.9* Not studied	 70.2 Not studied 74.8* Not studied
Sever et al, 1979[4]	Workplace.	a. Bosomat automatic BP recorder. b. Sitting. c. Lowest of the three.	Mean systolic and diastolic blood pressure	White Black	125 ± 15 131 ± 15	86 ± 9 91 ± 12***	117 ± 11 134 ± 16***	82 ± 10 96 ± 15***
Cruickshank et al, 1983[5]	Workplace.	a. Hawksley random zero. b. Sitting. c. First.	Age adjusted mean systolic and diastolic BP	White Black	138.2 133.6	80.9 81.9	131.5 136.6	76.2 82.3**
Haines et al, 1987[6]	Health centre.	a. Hawksley random zero. b. Not given. c. Mean of the two.	Mean systolic and diastolic BP	White Black	135.3 ± 19.7 134.1 ± 20.0	78.1 ± 13.9 79.1 ± 17.3	127.5 ± 21.6 123.6 ± 18.7	73.0 ± 13.9 72.5 ± 13.8
Miller et al, 1988[7]	Home.	a. Hawksley random zero. b. Supine. c. Average of the two.	Mean systolic and diastolic BP	European West Indian	138.0 141.1	86.1 86.3	Not studied	Not studied
Cruickshank et al,1991[8]	Health centre.	a. Hawksley random zero. b. Sitting. c. Average of the two.	Age adjusted mean systolic and diastolic BP	White Afro-Caribbean	129 ± 20 138 ± 18	77 ± 14 84 ± 12	128 ± 18 132 ± 19	75 ± 12 81 ± 11
McKeigue et al,1991[9]	Workplace and hospital clinic.	a. Hawksley random zero. b. Sitting. c. Not given.	Age adjusted median systolic and diastolic BP	European Afro-Caribbean	121 (121-122) 128 (125-128)	78 (77-78) 82 (80-82)	Not studied	Not studied
Chaturvedi et al, 1993[10]	Health centre.	a. Not given. b. Supine. c. Average of the two.	Age standardised median systolic and diastolic BP	European Afro-Caribbean	122 (120-126) 128 (125-133)**	79 (77-80) 84 (81-86)**	118 (115-120) 135 (131-140)***	75 (73-76) 86 (83-88)***

Table 2 continued

First author surname and date of publication	Setting	Measurement technique	Measurement reported	Blood pressure levels by sex and ethnic group: Ethnic group	Men SBP	Men DBP	Women SBP	Women DBP
Cappuccio et al, 1998[11]	Hospital clinic.	a. Automated ultrasound. b. Supine. c. Average of the last two.	Age adjusted mean systolic and diastolic BP	White African origin	127.9 (125.5-130.3) 133.8 (131.3-136.3)**	82.1 (80.7-83.4) 87.6 (86.2-89.0)***	123.5 (121.5-125.6) 134.1 (132.2-136.0)***	77.2 (76.2-78.3) 84.7*** (83.7-85.7)
Whitty et al, 1999[12]	Not given.	d. Not given. e. Not given. f. Average of the two.	Age adjusted mean systolic and diastolic BP	White Afro-Caribbean	123.4 125.7**	76.8 79.2***	120.0 124.5***	75.0 78.5***
Primastesta et al, 2000[13]	Home.	d. Dinamap 8100 monitor. e. Sitting. f. Average of the last two.	Age adjusted mean systolic and diastolic BP	White 16-39 40 and above Black 16-39 40 and above	 132.3* 141.6 129.5 147.4***	 70.3 81.5 69.7 84.4***	 122.8 138.0 122.5 143.6***	 68.1 75.8 68.7 79.6***
Karlsen et al, 2001[14]	Home.	a. Dinamap 8100 monitor. b. Sitting. c. Average of the last two.	Age adjusted mean systolic and diastolic BP.	 Gen. population B. Caribbean	SRM 136.8 1 136.4 1	SRM 76.2 1 74.7 1	SRM 132.5 1 129.4 1.01	Not given but no significant difference between the groups.
Cruickshank et al, 2001[15]	Health centre	a. Standard mercury. b. Sitting. c. Mean of the second and third.	Age-adjusted mean systolic and diastolic BP	European Afro-Caribbean	131.6 133.8	80.4 83.3	127.6 129.8	77.9 80.4
Lane et al, 2002[16]	Not given	a Hawksley random zero b Sitting. c Average of the two.	Mean systolic and diastolic BP	Caucasian Afro-Caribbean	129.7 135.6	80.4 81.8	123.0 134.5***	72.3 80.7***

BP = Blood Pressure, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, P = P value, SRM = Standardised ratio of mean, values in parentheses are 95% confidence intervals
*p<0.05, **p<0.01,***p<0.001, comparing ethnic groups

In 10 of 14 studies, mean systolic BP was higher in men from African descent than in white men.[3,4,7,8,9,10,11,12,16] In Primatesta *et al*'s national study, mean systolic BP was lower in the black group aged 16-39 years; however, in those aged 40 years and above, mean systolic BP was higher than in the white group.[13] In Karlsen *et al*'s national study,[14] the observed mean systolic BP was lower in Afro-Caribbean; however, once the effect of age had been controlled for and results were presented as standardised ratios of means, there was no difference between the two groups. In Cruickshank *et al*'s Birmingham Factory study and Haines *et al*'s study, the mean systolic BP was lower in black than in white populations.[5,6] For diastolic BP, all the studies reported higher mean values in black than in white groups, except Primatesta *et al*[13] in the 16-39 year age group and Karlsen *et al*.[14]

A total of 12 studies included women.[3,4,5,6,8,10,11,12,13,14,15,16] Of these, 10 studies[3,4,5,8,10,11,12,14,15,16] reported a higher and one study[6] reported a lower systolic BP in black than in white women. In Primatesta *et al*,[13] the younger black group had a lower and the older black group a higher mean systolic BP than the white group. For diastolic BP, with two exceptions,[6,14] one in which the levels were not given,[14] but stated as showing no difference, all the studies reported higher levels in black than in white groups.

The only study that compared systolic BP levels between Afro-Caribbeans and West Africans reported similar levels but the number of West Africans (men *n*=26, women *n*=25) was relatively small compared to Afro-Caribbeans (men *n*=211, women *n*=303).[10]

Prevalence of hypertension

Table 3 shows 12 studies[4,5,6,7,8,10,11,12,13,14,15,16] that reported on the prevalence of hypertension using various cutoff points. Most studies reported on a cutoff point of systolic BP of 160 mmHg or more and/or diastolic BP of 95 mmHg or more, and defining as hypertensive those receiving hypertension treatment. Three studies did not indicate the number of people who were receiving treatment for hypertension.[4,7,16] Two studies combined men and women.[4,12] One study did not standardise the prevalence rates for age.[4] Karlsen *et al*[14] reported on a cutoff point of 140/90 mmHg.

With one exception in which the treatment rate was slightly lower in Afro-Caribbean women than in white women,[8] all the studies reported higher treatment rates in men and women of African descent compared to white men and women.

A total of 10 studies reported on men.[5,6,7,8,10,11,13,14,15,16] Of these, eight studies reported higher prevalence rates in people from African descent than in white men.[5,6,8,10,11,14,15,16] In Primatesta *et al*,[13] the prevalence rate was lower in the 16-39 years age group, but higher in the 40 years and above age group in black compared to white men. Miller *et al*[7] reported lower prevalence rates in black men than in white men, but the number of black men were relatively small (*N*=24) compared to white men (*N*=68). Of the nine studies that included women, [5,6,8,10,11,13,14,15,16] seven studies[5,8,10,11,13,15,16] reported higher and one study[6] reported lower prevalence rates in people from African origin compared to white women. In Karlsen *et al*,[14] Black Caribbean women had lower observed prevalence rate than white women; however, once the effect of age had been standardised and presented in risk ratios, the Black Caribbean women had higher rate than white women. Two studies' results were based on both men and women combined and reported higher prevalence rates in black than in white populations.[4,12]

Anthropometry data and mean difference in BP

Table 4 shows, in studies ranked by African origin sample size, body mass index (BMI), waist-to-hip ratio (WHR), and mean difference in systolic and diastolic BP. In all, 11 studies reported on overall mean BMI on men.[3,6,7,8,9,10,11,13,14,15,16] Of these, six studies[3,9,11,13,14,16] reported higher BMI and five studies[6,7,8,10,15] reported lower BMI in African descent compared to white men. Overall, differences in BMI were small. Five studies reported on WHR on men.[8,9,11,14,15] Of these, three studies[11,14,15] reported lower, one study[9] reported the same and one study[8] reported higher ratios in African descent men compared to white men. Again, the differences were small. Nine studies reported on BMI[3,6,8,10,11,13,14,15,16] and four studies reported on WHR[8,11,13,15] on women and all reported higher BMI and WHR in Africans than in white population. The mean differences in systolic and diastolic BPs varied widely. The mean differences were particularly marked in women from African descent reaching 10.6-17 mmHg higher in some studies.[4,10,11,16] The patterns of BP were partly associated with BMI, the fit being better in women of African descent. For example, in four studies,[7,8,10,15] the mean BMI was lower in black men but mean BP levels were higher than those in white men.

Discussion

Key findings

Nearly all the studies were carried out in the London area where BP levels and prevalence of hypertension were higher in men and women of African descent as compared to the white population. The BP pattern was different in the younger age group than in older age groups in African compared to the white groups.[13] Treatment rates were higher in people from African descent compared to white people. Women of African descent consistently had comparatively high BMI and WHR but this did not apply to men.

Table 3 Criteria for diagnosis, age adjustment, receipt of treatment and prevalence of hypertension by sex and ethnic group							
First author surname and date of publication	**Criteria for diagnosis of hypertension**	**Age adjusted**	**Ethnic groups**	**Receipt of treatment by sex and ethnic group** **Men**	 **Women**	**Prevalence by sex and ethnic group** **Men**	 **Women**
Sever et al, 1979[4]	BP > 140/90 mm Hg & BP > 160/95 mm Hg		Whites BP >140/90 mm Hg BP >160/95 mm Hg Blacks BP >140/90 mm Hg BP >160/95 mm Hg	Not given	Not given	 8% 3% 28% 8% Men and women combined	
Cruickshank et al, 1983[5]	BP≥ 160/95 mm Hg or receiving anti-hypertensives	Yes	Whites Blacks	3.4% 4.6%	15.9% 27.7%	22.1% 26.0%	15.9% 27.7%*
Haines et al, 1987[6]	BP≥ 160/95 mm Hg	Yes	Whites Blacks	5.1% 8.9%	5.6% 7.1%	4.9% 8.0%	3.7% 1.4%
Miller et al, 1988[7]	BP≥ 160/95 mm Hg or receiving antihypertensive therapy	Yes	Europeans West Indians	Not given	Not studied	24% 21%	Not studied
Cruickshank et al,1991[8]	BP≥ 160/95 mm Hg or below these values if receiving anti-hypertensives	Yes	Whites Afro-Caribbeans	5% 21%	26% 25%	20% 35%	34% 47%
Chaturvedi et al, 1993[10]	BP≥ 160/95 mm Hg, treated hypertensives and those receiving antihypertensive therapy	Yes	Europeans Afro-Caribbeans	7.3% 21.0%***	10% 30.2%***	6.9% 10.6%	3.3% 7.2%
Cappuccio et al, 1998[11]	(WHO) criteria: BP≥ 160/95 mm Hg or on drug therapy and (JNC) criteria: BP≥ 140/90 mm Hg or on drug therapy	Yes	White: WHO criteria JNC criteria African Origin: WHO criteria JNC criteria	Not given	Not given	 18% 33% 37% 51%	 13% 24% 40% 54%
Whitty et al, 1999[12]	BP≥ 160/95 mm Hg on being on antihypertensives	Yes	Whites Afro-Caribbeans	9% 32%*** Men and women combined		OR 1 OR 4.0 (95% CI 2.8-5.7) Men and women combined	
Primastesta et al, 2000[13]	BP≥ 160/95 mm Hg and all those receiving antihypertensives	Yes	Whites: 16-39 40 and above Blacks: 16-39 40 and above	 Not given 19% Not given 36%***	 Not given 22% Not given 46%***	 4% 36% 2% 51%***	 2% 34% 3% 56%***
Karlsen et al, 2001[14]	BP≥ 140/90 mm Hg and all those receiving anti-hypertensive	Yes	 Gen. Population Black Caribbean	 8.5% 14.5%	 10.4% 14.9%	SRR 40.8% 1 41.9% 1.11	SRR 32.9% 1 28.8% 1.21
Cruickshank et al, 2001[15]	Relevant treatment or BP≥ 160/95 mm Hg	Yes	European African-Caribbean	Overall not given	Overall not given	19.5% 27.3%	10.3% 29.0%
Lane et al, 2002[16]	BP≥ 160/95 mm Hg and all those receiving antihypertensives	Yes	 Caucasians Afro-caribbeans	Not given	Not given	OR 19.4% 1 30.8% 1.56	OR 12.9% 1 34.4% 2.40

BP = Blood Pressure, OR = Odd Ratio, SRR = Standardised risk ratio*p<0.5, **p<0.01, ***p<0.001, comparing ethnic groups

Limitation of the review and included studies

In some studies, Afro-Caribbean and West Africans were combined as one ethnic group.[3,10,11,13] This method of combination is subjective, imprecise, and unreliable. Afro-Caribbean people have cultural values that are different from people of West Africa. In fact, the term West Africans is inappropriate because there are major ethnic differences between countries and also within countries in West Africa in terms of culture such as language, diet, religion, geography, and socioeconomic variations. All these factors are important determinants of health and have been shown to influence BP.[20] UK mortality statistics show that black Africans had higher mortality rates from chronic rheumatic heart disease and hypertensive disease than Afro-Caribbeans.[21] The studies span about 20 years, which potentially affects the comparability and interpretability of the results. Middle-age people of African descent at the end of the 20th century were likely to be different from their counterparts in the early 1980s, in terms of immigration, habits, and socioeconomic status. There are also many black people in the UK who have some white ancestry (mixed race), which further complicates interpretation. With one exception,[5] none of the authors in these reviewed papers stated whether mixed race people were included or excluded.

Huge variations in methods of measurement of BP limit the capacity to synthesise the data. For example, in seven studies participants' BPs were measured with a Hawksley random zero sphygmomanometer.[5,6,7,8,9,10,16] In other studies,[13,14] a Dinamap 8100 monitor was used that tends to provide higher systolic and lower diastolic BP levels than mercury sphygmomanometer readings.[22,23] Participants' BPs were measured in different locations. The readings analysed also varied. The estimated white coat hypertension ranges from 12 to 53% depending on the population studied and the definition used.[24,25] It is difficult to account for the effect of white coat hypertension in each study. It is also not clear whether the effect of white coat hypertension differs in different ethnic groups. Some studies did not take the effect of age on BP into account in their analysis,[3,4] which might have given misleading results. Karlsen *et al*'s[14] study highlights the importance of age adjustment when comparing BP levels between different ethnic groups. In this study, Black Caribbean men had lower observed BPs. However, once age was controlled for, the levels between Black Caribbean and the general population were no longer different.[14] Many people from African descent in the UK fall into the lower end of the socio-economic structure and this is a major potential confounding factor in most studies on ethnic differences in health. The few studies that reported on socioeconomic characteristics showed that people from African descent were clustered to the lower end of the social structure[11] or grade structure even in the same industry.[3,5,12,13,14] Studies did not formally adjust for socioeconomic confounders. Differences in BMIs and sex composition of the samples further complicate interpretation of these studies. These differences in study methods mean that between study differences are not reliable and focus attention on within study variations.

Some authors used name analysis to identify subjects with origins in West Africa.[9,11] West Africans and Afro-Caribbean people who share christian names with the white population are likely to be missed by this technique. In Cappuccio *et al*,[11] for example, using name analysis identified 80% of white people, 94% of West Africans but only 51% of the Afro-Caribbeans. The knowledge of practice staff was used to improve identification of this group. This could have resulted in selection bias, if people who were well known to the practices were more likely to be selected. Some studies[3,5,7,9] used country of birth as an indicator of ethnicity. This technique may exclude Afro-Caribbeans and West Africans born in the UK.

Huge variations in study methods might make it problematic for researchers to conduct a meta-analysis, which would require collecting the original data. Whether such a task is feasible and worthwhile needs to be assessed in further research.

Discussion of the key results

The findings of higher BP levels and a higher prevalence of hypertension in the people of African descent in the UK are confirmatory of the USA's African-American and white comparisons. Higher BP levels reported in most studies did not reflect the patterns shown by the Health Survey for England '99.[14] In Health Survey for England '99, standardised mean systolic and diastolic BP levels were similar in men in both ethnic groups.[14] The study also reported no significant difference in standardised mean diastolic BP in women. Little difference in BP between African Caribbeans and Europeans in this study probably reflects better treatment in African Caribbeans across the UK and this is indicated by the higher proportions on therapy (Table 3). The fact that the African Caribbeans included in the study came from all social strata may also be relevant.

A higher prevalence of hypertension was not always associated with higher BP in that population. The explanations for this are either that the percentage on antihypertensive treatment differs or the distribution of BP is skewed.[26] The former clearly applied. The higher rates of antihypertensive treatment reported in people from African descent is encouraging, given that there is concern about reduced access to health-care services among ethnic minority groups in the UK.[21] Higher rates of use of antihypertensives among people from African descent probably reflect awareness among doctors about the risk of hypertension and stroke in this ethnic group. The findings of higher BP levels and higher prevalence rates of hypertension in African descent are clear-cut in the older age groups but not the younger age groups. In Primatesta *et al*'s study, the younger black group had lower but the older black group had higher BP levels compared to whites. Also, in Cruickshanks *et al*'s study, the younger black group aged 15-24 years had a lower BP than the white age group.[5] Again, in Lane *et al*'s study, mean systolic and diastolic BPs were marginally lower in Afro-Caribbeans than in the white group in the <30-year-old age group.[15] In another two studies on school leavers (hence excluded from the tables), mean systolic and diastolic BPs were lower in the black groups than in the white groups.[27,28]Epidemiological studies have consistently shown an important and independent association between increased BP and cardiovascular disease, especially stroke and coronary heart disease.[29] Whether the physiological optimal level of BP is the same in each ethnic group is unknown.[30] Black hypertensives may have higher death rates from all causes than their white counterparts.[31] However, evidence to support this has not been consistent. Findings from the St James Study in Trinidad showed ethnic similarities, for example, the attributable mortality after 8 years from a systolic BP between 155 and 179 mmHg was 7.9 deaths/1000 person year for black and 8.2 for European men, and above 180 mmHg, 14.7 and 15.1, respectively.[32] Whether the arbitrary cutoff point for defining hypertension, for example the WHO criteria, will overestimate[33] or underestimate individual risk in different ethnic groups remains an open question.

In conclusion, BP levels and prevalence of hypertension are clearly higher in UK residents of African descent. Some of the inconsistent results in the UK studies could be explained by the variations in the methods of measurement of BP and the classification of black groups in some studies. Differences in BMI, age, and sex also further confound findings. Different BP patterns between younger and older age groups in people from African descent in the UK means that there is a case for epidemiological research, including a meta-analysis, examining BP levels and prevalence of hypertension in younger populations (including a review of data in children), and how this pattern may be changing. More research studies are needed in cities outside London. Future research must recognise the various subgroups of West Africans. They should be designed in such a way that data can be combined easily for future systematic reviews, for example by standardising the way in which BP is measured.

TABLE 4 Mean body mass index (BMI), waist-to-hip ratio (WHR) and mean difference in blood pressures by sex and ethnic group ordered by ranking on size of the African descent sample

First author surname & date of publication	Ethnic group.	No.	Anthropometry data				Mean difference (African descent – European descent)			
			Men		Women		Men		Women	
			BMI	WHR	BMI	WHR	Systolic	Diastolic	Systolic	Diastolic
Primastesta et al, 2000 [13]	Whites	52525	% Obesity	Not given		Not given				
	16-39	20906	10%		12%					
	40 and above	31619	18%		21%					
	Blacks	811								
	16-39	516	10%		21%***		- 2.8	- 0.6	- 0.3	0.7
	40 and above	295	19%		41%***		5.8	2.9	5.6	3.8
Karlsen et al, 2001[14]			SRR	SRR	SSR	SRR	SRM	SRM	SRM	Not given but no significant difference
	Gen. Population	11884	1	1	1	1	1	1	1	
	Black Caribbean	719	1.02	0.62	1.60	2.09	- 0.4 1	- 1.5 1	- 3.1 1.01	
Chaturvedi et al,1993[10]	Europeans	585	26.4	Not given	26.0	Not given				
	Afro-Caribbeans	581	26.0		29.1**		6.0	5.0	17.0	11.0
Lane et al, 2002[16]	Caucasian	2169	Overall not given but higher in Afro-Caribbeans	Not given	Overall not given but higher in Afro-Caribbeans	Not given				
	Afro-Caribbean	453					5.9	1.4	11.5	8.4
Cappuccio et al, 1998 [11]	Whites	523	25.8	0.92	26.1	0.798				
	African origin	549	26.4***	0.92	29.3***	0.832***	5.9	5.5	10.6	7.5
Cruickshank et al, 2001[15]	Europeans	558	27.2	0.921	27.0	0.803				
	African Caribbean	480	26.7	0.899	28.9	0.816	2.2	3.0	2.2	2.5
Haines et al, 1987[6]	Whites	936	25.3	Not given	25.2	Not given				
	Blacks	415	25.0		25.8		- 1.2	1.0	- 3.9	- 0.5
Whitty et al, 1999 [12]	Whites	8973	Not given	Not given	Not given	Not given				
	Afro-Caribbeans	360					2.3	2.4	4.5	3.5
Cruickshank et al, 1983[5]	Whites	330	Overall not given	Not given	Overall not given	Not given				
	Blacks	274					- 4.6	1.0	5.1	6.1

Table 4 continued

First author surname & date of publication	Ethnic group.	No.	Anthropometry data				Mean difference (African descent–European descent)			
			Men		Women		Men		Women	
			BMI	WHR	BMI	WHR	Systolic	Diastolic	Systolic	Diastolic
McKeigue et al,1991[9]	Europeans	1515	25.9	0.94	Not studied	Not studied			Not studied	Not studied
	Afro-Caribbean	209	26.3	0.94			7.0	4.0		
Meade et al, 1978[3]	Whites	412		Not given		Not given				
	Day Shift		24.4		23.6					
	Night Shift		25.2		Not studied					
	Blacks	141								
	Day Shift		24.5		27.4		7.8	6.0	6.8	4.6
	Night Shift		25.8		Not studied		4.4	5.0	Not studied	Not studied
Cruickshank et al,1991[8]	Whites	101	26.2	0.914	26.3	0.835				
	Afro-Caribbean	106	26.0	0.918	29.1	0.882	9.0	7.0	4.0	6.0
Sever et al, 1978[4]	Whites	62	Not given	Not given	Not given	Not given				
	Blacks	53					6.0	5.0	17.0	14.0
Miller et al, 1988[7]	Europeans	68	26.6	Not given	Not studied	Not studied			Not studied	Not studied
	West Indians	24	24.9				3.1	0.2		

SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, *$p<0.05$, ** $p<0.01$, *** $p<0.001$, comparing ethnic groups, SRR = Standard risk ratios of means
SRM = Standardised risk ratios of mean

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Do variations in blood pressures of South Asian, African and Chinese descent children reflect those of the adult populations in the UK? A review of cross-sectional data

Charles Agyemang[1]

Raj Bhopal[2]

Marc Bruijnzeels[1]

[1]Institute of Health Policy and Management, Erasmus Medical Center, The Netherlands

[2]Public Health Sciences, Division of Community Health Sciences, College of Medicine and Veterinary Medicine, University of Edinburgh, Teviot Place, Edinburgh, UK

Published in *Journal of Human Hypertension* 2004; **18**:229-237

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Abstract

The objective of this study was to assess whether variations in BP in children of UK ethnic minority populations correspond to those seen in adults. A systematic literature review was carried out using MEDLINE 1966-2003 and EMBASE 1980-2003, supplemented by correspondence with expert informants, and citations from references. Five studies were identified. There were important differences between studies in terms of age and sex of samples, definition of ethnic minority children and methods of evaluating BP. Three studies of children of African descent reported lower mean SBP in boys from African descent compared to white boys, the differences being significant only in one study. In African descent girls, the mean SBP was significantly lower in one study, while DBP was significantly higher in one study. Four studies included children of South Asian origin. The Health Survey for England '99 reported on South Asian groups separately. Pakistani boys had a significantly higher age- and height-standardised mean SBP than the general population. The mean DBP was significantly higher in Indian and Pakistani boys than the general population. Pakistani and Bangladeshi girls had a significantly higher mean DBP than the general population. The other three studies, which combined South Asian subgroups found no significant differences in the mean BP between South Asians and white subjects. One study included children of Chinese descent and reported significantly higher mean DBP in Chinese boys and girls compared to the general population. Overall, BP across ethnic groups was similar. These similarities in BP patterns particularly in African, Bangladeshi and Pakistani descent children contrasts with those in the corresponding adult populations in the UK where BP is comparatively high in those of African descent and comparatively low in those of Bangladeshi and Pakistani descent.

Keywords: ethnicity; African descent; South Asian descent; children; blood pressure

Introduction

Systematic reviews on adult populations in the UK have shown that compared to the white, European origin populations, the mean SBP and DBP are similar in people of South Asian descent[1] but higher in those of African descent.[2] However, there was a stark heterogeneity among South Asian subgroups, with Indians having similar BP, Pakistanis having slightly lower BP and Bangladeshis having much lower BP than whites.[1] Two adult studies on Chinese origin populations in the UK have given inconsistent results.[3,4] In Harland *et al*'s study, the mean SBP and DBP were lower in Chinese men but higher in Chinese women compared to white people,[3] whereas in the Health Survey for England '99, Chinese men and women had a lower mean SBP and DBP than for men and women in the general population.[4] BP levels were comparatively high in Chinese adults living in Manchester, UK than in Chinese adults living in mainland China in all age groups.[5] This review investigates whether ethnic variations in BP in children (⩽16 years of age) of ethnic minority populations reflect those of the adult populations in the UK.

Methods

Search strategy

EMBASE and MEDLINE searches identified papers published from 1980 to 2003 and 1966 to 2003, respectively. Medical Subject Heading (MeSH) 'Asians' or 'South Asians' or 'Caribbean and Asian' or 'Indians', or 'Pakistanis', or 'Bangladeshis', or 'Africans' or 'African Caribbean', or 'West Africans', or 'blacks', or 'Chinese', or 'ethnic minority population' were combined with 'blood pressure' and 'hypertension'. The search was limited to the UK and papers published in English. We included studies that reported BP and/or prevalence data on community-based samples of ethnic minority children in comparison with a white or general population in the UK. All studies based on clinically selected patients and on adults were excluded. The reference list of all known primary studies and review articles were scrutinised and additional relevant citations were identified. Five studies were examined.[6,7,8,9,10] One author[10] supplied unpublished data. We contacted five experts, listed in the acknowledgements, in ethnicity and health to advise us if they knew of any other studies, but none was identified.

Study selection and data extraction

Of the five studies included in the final analysis, four were cross-sectional surveys[6,7,9,10] and one study reported cross-sectional data from a cohort design.[8] Two studies were designed specifically to focus on BP levels,[6,7] the rest had broad aims relating to a range of cardiovascular risk factors.[8,9,10]

Results

Methods of the review studies

Table 1 shows that four studies were carried out in England,[6,7,8,9] and one study was carried out in England and Wales.[10] Two studies reported the time the fieldwork was conducted.[9,10] Three study samples were based in schools,[6,7,10] one study was based on the Local Child Health and National Health Service Central Register[8] and one study used community-based sampling.[8] The investigators' observation of appearance,[6] country of origin,[8] self-reported ethnic origin or parental report,[9] and appearance cross-checked with surname and parental place of birth[10] were the indicators of ethnicity. In Khaw and Marmot's study, the indicator of ethnicity was not given.[7] The age range varied between studies. Four studies assessed boys and girls separately,[6,7,9,10] but one study combined them.[8] The response rate varied from 59%[8] to 87%.[7] The largest and the most representative sample came from the Health Survey for England '99.[9]

Blood pressure

Table 2 shows that BP was measured in three studies at school[6,7,10] and in two studies at home[8,9] using a Hawskley random zero sphygmomanometer,[6,7] a Dinamap 1846SX[8,10] and a Dinamap 8100 monitor[9] all in a sitting position. The readings reported varied - mean SBP and DBP of the first reading,[6] the mean SBP and DBP of the two readings taken,[7,10] and the mean SBP and DBP of the last two readings of three.[9]

BP in children of African descent

Three studies included children of African descent.[6,7,9] De Giovanni *et al* reported lower mean SBP and DBP in black boys compared to white boys. For girls, black subjects had a lower mean SBP but a higher DBP compared to the white subjects.[6] There was no significant difference in either SBP or DBP between these ethnic groups. Khaw and Marmot's study showed that black boys had a significantly lower mean SBP in both schools compared to white boys. The mean DBP was lower in KDC School but higher in BHS School in black boys compared to white boys, although the differences were not significant in both schools. For girls, the mean SBP was higher in KDC School but lower in BHS School. Black girls at the KDC School had a significantly higher DBP compared to white girls. The mean DBP in BHS School was lower in black girls but the differences were not significant. Nazroo *et al* reported a higher mean SBP and DBP in black Caribbean boys than for boys in the general population. However, after controlling for age and height using linear regression, the mean SBP was lower by 0.22 mmHg in black Caribbean boys compared to boys in the general population. For girls, black Caribbeans had a lower mean SBP but a higher DBP compared to the general population. After controlling for age and height, black Caribbean girls had a significantly lower SBP than for girls in the general population.[9]

BP in children of South Asian descent

Four studies included children of South Asian origin.[6,8,9,10] Clark *et al*'s study was based on boys and girls combined,[8] and reported higher SBP and DBP in South Asian children compared to white children. De Giovanni *et al*[6] reported lower mean SBP and DBP in Asian boys and girls than in their white counterparts. Whincup *et al*[10] reported a higher mean SBP and DBP in South Asian boys compared to white boys but the differences were not significant. For girls, South Asians had a lower mean SBP but a higher DBP compared to the white subjects.[10] None of these three studies[6,8,10] found significant differences in mean SBP and DBP between South Asian and white children. The Health Survey for England '99 reported on South Asian subgroups separately and reported a higher observed mean SBP in Indian, Pakistani, and Bangladeshi boys compared to boys in the general population. Pakistani boys had significantly higher mean SBP than the boys in the general population after controlling for age and height. Indian, Pakistani and Bangladeshi boys also had a higher observed mean DBP than the general population. After age and height had been standardised, mean DBP was significantly higher in Indian and Pakistani boys than the boys in the general population. Among girls, the observed mean SBP was lower in Indians and Bangladeshis but higher in Pakistanis compared to the general population. For DBP, Indian, Pakistani, and Bangladeshi girls had higher levels than girls in the general population.[9] These observations held after age and height standardisation, but the differences were significant only in Pakistani and Bangladeshi girls.

BP in children of Chinese descent

Only the Health Survey for England '99 included children of Chinese origin and reported higher observed mean SBP and DBP in Chinese boys than for boys in the general population. After age and height had been controlled for, the mean DBP was significantly higher in Chinese boys than for boys in the general population. For girls, the observed mean SBP was lower but DBP was higher in Chinese than for girls in the general population. After controlling for age and height, the mean DBP was significantly higher in Chinese girls than for girls in the general population.[9]

Anthropometry data and mean difference in BP

Table 3 shows, in studies ranked by ethnic minority children sample size, weight, height, body mass index (BMI), waist-to-hip ratio (WHR) and mean difference in SBP and DBP.

Table 1 Contextual details

First author surname and date of publication	Place, Time of study, Study design and Sampling frame	Aim	Indicator of ethnicity	Age group studied	Sample size by ethnic group	Response rate
De Giovanni et al (1983)[3]	a. Birmingham b. Not given c. Cross-sectional study d. 4 schools	To screen school leavers of three ethnic groups for blood pressure, resting pulse rate and general anthropometric characteristics.	Observation	15.4-15.7	White 138 Male 68, female 70 Asian 178 Male 76, female 102 Black 110 Male 68, female 70	Not given
Khaw et al (1983)[4]	a. London b. Not given c. Cross-sectional study d. 2 schools	To determine if ethnic differences in mean blood pressures were discernible in adolescent school children.	Not given	15-16	White 177 Male 100, female 77 Black Male 60, female 58	87%
Clark et al (1998)[5]	a. West Midlands b. Not given c. Cohort d. Local child health and NHS Central Register	To determine whether women who are poorly nourished in early pregnancy or who have poor pregnancy weight gain have offspring with higher blood pressure.	Country of origin	11.0	White 137 Asian 159	59%
Kalsen et al (2001)[6]	a. England b. 1999 c. Cross-sectional study d. Selected postcode sectors	General health survey for England	Self-reported based on ethnic origin	5-15	General population Boys 2429, Girls 2425 Black Caribbean 335 Boys 161, girls 174 Indian 267, Boys 149, girls 118, Pakistanis 387 Boys 193, girls 194 Bangladeshi 294 Boys 152, girls 142 Chinese 162, Boys 85 Girls 77	60% for ethnic minority groups
Whincup et al (2002)[7]	a. England and Wales b. 1994 c. Cross-sectional study d. 10 towns in England & Wales	To examine whether British South Asian children differ in insulin resistance, adiposity, and cardiovascular risk profiles from white children.	Appearance, cross checked with surname and parental place of birth	8-11	White 3415 Boys 1769, girls 1646 South Asian 227 Boys 121, girls 106	73% for whites and 80% for South Asians

Table 2 Setting, measurement technique and mean systolic and diastolic pressure by sex and ethnic group

First author surname and date of publication	Setting of measurement	a. Sphygmomanometer b. Position c. Reading taken for analysis	Ethnic groups	Boys n	Boys Systolic	Boys Diastolic	Girls n	Girls Systolic	Girls Diastolic
De Giovanni *et al* (1983)[6]	School	a. Hawksley random zero b. Sitting c. First reading (of two taken)	White	68	122.5 (13.9)	66.7 (11.3)	70	118.0 (13.8)	65.7 (11.8)
			Black	76	121.0 (11.9)	64.1 (13.5)	102	117.0 (12.2)	66.9 (9.9)
			Asian	68	117.8 (15.4)	60.8 (12.4)	70	115.6 (11.8)	63.8 (12.2)
Khaw & Marmot (1983)[7]	School	a. Hawksley random zero b. Sitting c. Average of the two readings	KDC School						
			White	81	114.4 (13.6)	64.2 (12.9)	19	102.9 (13.8)	60.9 (9.8)*
			Black	38	108.2 (11.1)*	63.9 (11.1)	22	103.4 (9.0)	67.3 (11.9)
			BHS School						
			White	57	119.3 (11.1)	70.1 (10.1)	20	112.9 (14.0)	72.8 (12.3)
			Black	19	112.0 (6.9)*	72.5 (11.1)	39	110.1 (12.1)	71.6 (10.3)
Clark *et al* (1998)[8]	Home	a. Dinamap 1846 SX recorder b. Sitting c. Average of the three readings	White	137	104.0 (11.0)	60.0 (11.0)	(Boys and girls mixed)		
			Asian	159	107.0 (13.0)	63.0 (7.0)			
					RC[a]	RC[a]		RC[a]	RC[a]
Nazroo *et al* (2001)[9]	Home	a. Dinamap 8100 monitor b. Sitting c. Average of the last two readings	Gen. Population	2429	111.1 0	56.8 0	2425	111.0 0	57.5 0
			Black Caribbean	161	112.0 -0.22	57.1 0.14	174	110.3 -1.89¶	58.2 0.42
			Indian	149	113.5 1.44	59.7 2.87¶	118	109.9 -1.70	59.2 1.43
			Pakistani	193	112.6 2.88¶	60.9 4.23¶	194	111.6 0.17	59.2 1.52¶
			Bangladeshi	152	111.9 1.87	58.0 1.48	142	110.5 -0.42	60.5 3.27¶
			Chinese	85	111.9 1.97	59.4 3.14¶	77	108.7 0.68	60.1 2.79¶
Whincup *et al* (2002)[10]	School	a. Dinamap 1846 SX recorder b. Sitting c. Average of the two readings	White	1769	111.5 (0.3)	65.5 (0.2)	1646	113.3 (0.3)	65.5 (0.2)
			South Asian	121	112.0 (0.8)	67.1 (0.8)	106	111.3 (1.3)	65.9 (0.7)

RC[a] = Regression coefficient, equivalent to absolute difference in mean SBP & DBP standardised for age and height, compared with the general population. The reference value for the general population is 0
*p<0.05, ¶ stated that the difference was significant but the level was not given

Table 3 Mean weight, height, body mass index (BMI), waist-to-hip ratio (WHR) and mean difference in blood pressures by sex and ethnic group – Studies ranked on size of the ethnic minority children sample.

First author surname & date of publication	Age group studied (years)	Ethnic group.	No. Boys	No. Girls	Anthropometric data: Boys Weight	Boys Height	Boys BMI	Boys WHR	Girls Weight	Girls Height	Girls BMI	Girls WHR	Mean difference (ethnic minority-European descent): Boys SBP	Boys DBP	Girls SBP	Girls DBP
Nazroo et al (2001)[9]	5-15				RC[b]	RC[b]	RM	Not given	RC[b]	RC[b]	RM	Not given	RC[a]	RC[a]	RC[a]	RC[a]
		Gen. population	2429	2425	32.9 0	132.1 0	17.8 1		32.8 0	130.6 0	18.1 1		0	0	0	0
		Black Caribbean	161	174	36.2 1.66¶	137.1 2.27¶	18.2 1.02		36.3 3.59¶	132.6 2.65¶	19.1 1.05		-0.22	0.14	-1.89¶	0.42
		Indian	149	118	36.2 1.11	135.0 0.59	18.4 1.04		33.2 -1.63¶	131.9 -1.57¶	18.1 1		1.14	2.87¶	-1.70	1.43
		Pakistani	193	194	30.8 0.87	127.5 0.38	17.8 1		33.7 -0.07	131.3 -0.80	18.4 1.01		2.88¶	4.23¶	0.17	1.52¶
		Bangladeshi	152	142	30.6 -2.20¶	130.0 -2.15¶	17.1 0.96		30.9 -2.44¶	129.4 -3.00¶	17.8 0.98		1.87	1.48	-0.42	3.27¶
		Chinese	85	77	32.6 -1.14	131.7 -2.18¶	17.8 1		32.5 -3.63¶	131.4 -3.99¶	17.7 0.97		1.97	3.14¶	-0.68	2.79¶
Whincup et al (2002)[10]	8-11				Boys and girls combined				Boys and girls combined							
		White	1769	1646	35.8 (0.1)	140.9 (0.1)	12.70 (0.03)	0.816 (0.002)				0.781 (0.002)	0.5	1.6	-2.0	0.4
		South Asian	121	106	34.5 (0.6)*	140.5 (0.5)	12.27 (0.15)†	0.824 (0.009)				0.788 (0.009)				
De Giovanni et al (1983)[6]	15.4-15.7	White	68	70	Figures not given but stated that black boys and girls were heavier than white boys and girls. Asian boys and girls were lighter compared to white.											
		Black	68	70									-1.5	-2.6	-1.0	1..2
		Asian	7 6	102									-4.7	-5.9	-2.4	-1.9
Clark et al (1998)[8]	11	White	137		Figures were not given but stated that Asian children were heavier than white.											
		Asian	157										3.0	3.0		
		(Boys & girls combined)											(Boys & girls combined)			
Khaw & Marmot (1983)[7]	15-16	KDC School				Not given	Not given	Not given		Not given	Not given	Not given				
		White	81	57	59.7 (9.8)				55.1 (10.3)							
		Black	38	19	60.5 (9.0)				58.1 (8.7)				-6.2*	-0.3	0.5	6.4*
		BHS School														
		White	19	20	61.8 (11.7)				58.6 (10.4)							
		Black	22	39	64.2 (9.5)				59.6 (11.1)				-7.3*	2.4	2.8	-1.2

SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, RM = Ratios of mean BMI's

RC[a] = Regression coefficient, equivalent to absolute difference in mean SBP & DBP standardised for age and height, compared t with general population. The reference value for the general population is 0.

RC[b] = Regression coefficient, equivalent to absolute difference in mean weight/height standardised for age, compared to general population. The reference value for the general population is 0.

*$p<0.05$, †$p<0.01$, ¶ stated that the difference was significant but the level was not given.

Anthropometry and mean BP difference in children of African descent

In the Health Survey for England '99, Black Caribbean boys and girls were taller, heavier, and had a higher mean BMI than boys and girls in the general population.[9] These differences held and were significant after the age had been standardised. Nonetheless, SBP was lower but DBP was higher in black Caribbean boys and girls compared to boys and girls in the general population. Khaw and Marmot reported on mean weights only. Black boys and girls were heavier than their white counterparts in both schools, although the differences were not significant.[7] The mean SBP difference was particularly marked in boys in both schools being -6 to -7 mmHg lower in black boys compared to their white counterparts. De Giovanni *et al*[6] stated that black boys and girls were heavier than their white counterparts although the results were not given. SBP and DBP were lower in black children compared to white children except in black girls where DBP was higher.

Anthropometry and mean BP difference in children of South Asian descent

The Health Survey for England '99 showed that Bangladeshi boys and girls were shorter, lighter and had a lower mean BMI than for boys and girls in the general population.[9] These differences held after age had been standardised. Indian boys were taller, heavier, and had a higher mean BMI than boys in the general population. Indian girls were taller, heavier and had a similar mean BMI compared to their counterparts in the general population. However, after the effect of age had been controlled for, Indian boys and girls were significantly shorter than the boys and girls in the general population. Pakistani boys were shorter and lighter but had a mean BMI similar to that of boys in the general population. Indian and Bangladeshi girls had a lower SBP but a higher DBP mean difference compared to the girls in the general population. BP was mostly higher in South Asian children than children in the general population except in Indian and Pakistani girls in whom SBP was lower.[9] In Whincup *et al*,[10] South Asian children were shorter, significantly lighter and had a lower BMI but a higher WHR than white children. SBP and DBP were higher in South Asian boys compared to white boys. South Asian girls had a lower SBP but a higher DBP compared to white girls. De Giovanni *et al* stated lower[6] and Clark *et al* stated higher[8] body weights in South Asian children than their white counterparts although results were not given. The mean BP was lower in De Giovanni *et al*'s study[6] and higher in Clark *et al*'s study.[8]

Anthropometry and mean BP difference in children of Chinese descent

Chinese boys were shorter, lighter and had a similar BMI compared to boys in the general population. Chinese girls were taller, lighter and had a lower BMI compared to girls in the general population. However, after age standardisation, Chinese boys and girls were significantly shorter than the boys and girls in the general population. SBP and DBP were higher in Chinese boys than boys in the general population. The mean SBP was lower but DBP was higher in Chinese girls than girls in the general population.[9]

Some patterns of BP were associated with body weight and BMI, the fit being better on South Asian children in De Giovanni *et al*[6] and Clark *et al*[8] studies, and Indian boys in Nazroo *et al*'s[9] study.

Discussion

Key findings

Few studies provided BP comparisons by ethnic group in children in the UK and only one study reported on Chinese children. Overall, unlike in adults, ethnic variations were small. In children of African descent, the two earlier studies[6,7] showed lower mean BP levels, the differences being significant in one study,[7] while the most recent study[9] showed a similar age- and height-standardised mean SBP and DBP in boys compared to the white subjects. The data show a lower SBP but a higher DBP in girls of African descent compared to white girls. Most studies reported similar mean BP levels in children from South Asian descent compared to their white counterparts. The Health Survey for England '99 data show important differences between South Asian subgroups,[9] yet the rest of the studies combined them as one homogeneous group. Chinese boys and girls had a significantly higher age- and height-standardised mean DBP than boys and girls in the general population.[9]

Limitations of the review

The interpretation of the results is not straightforward due to the small number of studies; the different mixes of Afro-Caribbeans and West Africans and South Asian subgroups (Indians, Pakistanis and Bangladeshis) in the samples, incomplete description of the samples, and differences in methods between studies. These variations imply that between-study differences are not interpretable and focus attention on within-study differences. The importance of heterogeneity among people of African descent[11] and South Asian subgroups[12] has been stressed but is often ignored.

Variations in methods of measurement of BP limit the capacity to combine the data. For example, the children's BPs were measured in different locations with different techniques. The readings analysed varied. It is estimated that white-coat hypertension ranges from 44 to 88% in children depending on the population studied and definition used.[13,14] It is hard to account for the effect of white-coat hypertension in each study. It is also not clear whether the effect of white-coat hypertension differs in different ethnic groups.[2] Ethnic differences in body size and shape further complicate interpretation of these studies.

Discussion of the key findings

Children of African descent

The similar BP levels reported in children from African descent are in contrast with the higher BP levels among older adults[2] and African-American children in the US.[15] Most studies in the US have found higher BP in African-American children than in white children.[16,17,18,19,20] In some of these USA studies, ethnic differences in BP were still present after adjusting for age, weight, height, and BMI.[16,17] The UK result is still more unexpected in the face of a comparatively high BMI in African descent children. This finding of similar BP in children of African descent is consistent with the findings of similar BP levels in the younger African groups in the UK's adult studies.[2] For instance, in Primatesta *et al*'s[21] study, the younger black group had lower, but the older black group had higher, BP levels compared to the white group. In Cruickshanks *et al*'s[22] study, the younger black group aged 15-24 years had a lower BP than the white group. In Lane *et al*'s[23] study, the mean SBP and DBP were marginally lower in Afro-Caribbeans than in the white subjects in those under 30 years of age. These findings suggest that BP levels change differently with African groups, having a quicker rise at middle age compared to the white population in the UK. Alternatively, there are major generational changes. This question requires a cohort study that tracks changes from early life through to late middle age. These observations imply that the comparatively high BP in African origin populations in the UK is a controllable problem with appropriate interventions. They also favour environmental rather than genetic causation, for it is hard to image genetic factors where the effect is delayed to later adult life. It may be that young people of African origin can be protected from the high risks of stroke their older counterparts have.[24]

Children of South Asian descent

Higher DBP in South Asian boys is consistent with the higher DBP levels in South Asian adults reported by Agyemang and Bhopal.[1] Lack of consistent results in mean SBP and DBP in South Asian children also mirrors the findings of the UK adult studies.[1] The Health Survey for England '99 is the only study that examined South Asian subgroups.[9] Pakistani and Bangladeshi boys had a higher age- and height-standardised SBP than Indian boys. Pakistani and Bangladeshi girls had a higher age- and height-standardised mean SBP and DBP than Indian girls. A higher mean BP level in Bangladeshi children compared to the white children is very surprising given that the Bangladeshi adult population, overall, have much lower SBP and DBP compared to other ethnic groups in the UK.[1] Bangladeshi children have this high BP despite having a comparatively low BMI. These findings and the contrasts between adults and children highlight the importance of studying South Asian subgroups separately rather than mixing them as one homogeneous group, which may make other studies misleading. Bangladeshi adults, despite their low BP, have extremely high rates of stroke and coronary heart disease. The loss of the protective effect of low BP in Bangladeshi children does not augur well for the future.[24]

Children of Chinese descent

Higher BP levels reported in Chinese children in Health Survey for England '99, despite lower BMI, differ from those of the adults in the same survey. In the adults, Chinese men and women had lower age-standardised ratios of mean BP than for men and women in the general population.[4] In Harland *et al*'s[3] study, mean SBP and DBP were lower in Chinese men but higher in Chinese women compared to the white subjects. Horatio Wan's recent study revealed that Chinese men and women in Manchester had a higher mean SBP and DBP compared to their counterparts in mainland China. Prevalence of hypertension among Manchester Chinese men (38.29%) and women (39.24%) in this survey on Chinese descent in the UK is a cause for concern.[5] This corresponds with comparatively high risk of stroke in Chinese men and women in the UK.[24]

Anthropometry and ethnic minority children

While body shapes and weights may explain, at least in part, higher observed mean SBP and DBP in black Caribbean and Indian children, respectively, they do not clearly explain higher BP levels in Chinese children, Bangladeshi children, and in Pakistani boys in Nazroo *et al*'s study.[9] The finding of higher body weight and BMI in children of African descent is consistent with the finding in adult studies in the UK.[2] However, a higher body weight but a lower BP in children from African descent[6,7] and *vice versa* in Bangladeshi children[8] is very difficult to explain and in direct contrast with the adult studies.[1,2] It may be that environmental risk factors are more important than body shape and weight in childhood. For example, Clark *et al*'s[8] study found an association between reduced pregnancy weight gain and higher BP in the 11-year-old offspring of women who were malnourished in early pregnancy.[8] Foetal and early life growth patterns may be shaping these ethnic variations in BP in ways that we do not understand. It is clear, however, that the younger generation of ethnic minority groups have different BP patterns than the previous generation.

In conclusion, variations in BP patterns in ethnic minority children differ from those corresponding adult populations in the UK. Some of the inconsistent results in the UK studies could be explained by the classifications of ethnic minority children and differences in methods of measurement of BP. Variations in age, sex, and body shape and weight also possibly confound findings. There is a strong case for large-scale epidemiological research in ethnic minority children to examine BP levels and the change in this pattern with increasing age. Future research must acknowledge the various subgroups of South Asian and African children and should be designed in such a way that data can be synthesised more easily for systematic reviews.

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Does the white-coat effect in people of African and South Asian descent differ from that in the European origin white people? A systematic review and meta-analysis

Charles Agyemang[1]

Raj Bhopal[2]

Marc Bruijnzeels[1]

W.Ken Redekop[1]

1. **Institute of Health Policy and Management, Erasmus Medical Center, Rotterdam, The Netherlands**
2. **Public Health Sciences, University of Edinburgh College of Medicine and Veterinary Medicine, Teviot Place, Edinburgh, UK**

Published in *Blood Pressure Monitoring* 2005; **10**:243-8

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Abstract

Objective: To assess whether the white-coat effect (WCE) in people of African (Black) and South Asian descent differs from that of European origin white people (White), and if so, whether this explains demonstrated ethnic variations in blood pressure (BP).

Methods: A systematic literature review was carried out using Medline 1966-2003 and Embase 1980-2003, and citations from references. The meta-analysis was performed using Cochrane review manager software (RevMan version 4.2; Oxford, UK).

Results: Eight studies were examined, four studies from the UK and four from the USA. The mean systolic and diastolic WCE was similar in Blacks compared with Whites. The weighted mean difference (WMD) in systolic WCE was 0.59 (95% CI = -1.67, 2.85; p = 0.61) and in diastolic WCE was 0.18 (95% CI = -1.70, 1.35; *P* = 0.82). Two studies reported on South Asians. Both systolic and diastolic WCE was significantly lower in South Asians compared to Whites; the WMD in systolic WCE was –8.90 (95% CI = -13.04, -4.76, *P*< 0.0001) and in diastolic WCE was –4.66 (95% CI = -7.29, -2.03, *P*< 0.0001).

Conclusion: The BP differences between Blacks and Whites are unlikely to be a result of variations in WCE. The lower clinic BP levels in some South Asian groups might be partly caused by a low WCE but more studies are needed in this subject.

Key Words: Ethnic variations; African descent; South Asian descent; white-coat effect

Introduction

High blood pressure (BP) is a common problem in the general population, and the rates are even higher in some ethnic minority groups,[1-3] particularly in black African origin populations in Western countries.[2-4] The reasons for ethnic differences in BP and prevalence of hypertension are unclear, although several suggestions have been made including genetic and environmental factors.[5] Whilst the standard clinical BP measurement is of value, it is unreliable in some individuals. A single reading may be as much as 20 mmHg above or below the true value due to its continuous and unpredictable variability.[6] The transient pressor rise in a clinical setting, which is usually referred to as white-coat effect (WCE),[7] further complicates these problems. The causes of this white-coat phenomenon have not yet been fully established. It has, however, been suggested that clinicians measuring BP in the clinical environment may trigger an alerting reaction and a rise of pressure in some individuals.[7] Mancia and colleagues found that the entry of the physician into patient's room raised the patient's BP by an average of 20/10 mmHg.[7] Evidence suggests that the likelihood of the phenomenon increases in subjects with low education levels, high perceived stress levels, hypertension with recent onset, old age, and in females and non-smokers.[8,9] This makes diagnosis and management of hypertension difficult. The WCE also poses a problem in comparing ethnic differences in BP and prevalence of hypertension. It is unclear whether the transient pressor rise varies in different ethnic groups, and whether these variations could explain, at least in part, some of the ethnic differences in BP and prevalence of hypertension rates seen in Western countries.[1,2,10] We, therefore, assessed whether the transient pressor rise (WCE) in people of African and South Asian descent differ from that of European origin white populations, if so, whether this explains demonstrated ethnic differences in BP.

Methods

Search strategy and inclusion criteria

EMBASE and MEDLINE searches identified papers published from 1980-2003 and 1966-2003, respectively. Medical Subject Heading (MeSH) "Asians" or "South Asians" or "Caribbean and Asian" or "Indians", or "Pakistanis", or "Bangladeshis", or "Africans" or "African Caribbean", or "West Africans", or "blacks", or "racial stock" or "ethnic minority population" were combined with "WCE", "ABP", "ABP monitoring" "ambulatory intra-arterial BP", "diurnal BP" and "circadian BP". Personal files were checked and reference lists in the papers were examined. We included studies that reported office BP and daytime ABP (both invasive and non-invasive techniques) on samples of ethnic minority groups in comparison with a White or general population. The studies on non-invasive techniques were included if the devices used to measured ABP had successfully been validated by using established protocols of the European Hypertension Society or British Hypertension Society or Association for the Advancement of Medical Instrument, and the average daytime ABP was based on ≥ 10 readings. The difference between clinic BP and average daytime ABP is widely used as a surrogate measure of the WCE[11,12] on the assumption that ABP monitoring techniques make it possible to obtain BP values outside clinical settings that are not influenced by the stressful condition associated with clinic BP measurement.[12] This measure of WCE is used in this study since data for other methods are not available.

Study selection and data extraction

Eight studies were examined,[13-20] four studies from the UK[14,17,18,19] and four from the United States.[13,15,16,20] We report the ethnic group terms used in the original publications. With the exception of one study[19] that reported a cross-sectional survey from a cohort study, all the studies were cross-sectional surveys. The 95% confidence intervals and *p*-values are reported as given in the papers. We calculated mean systolic and diastolic WCE by subtracting mean daytime BP from mean office BP, and derived standard deviations. We used Cochrane review manager software (RevMan version 4.2; Oxford, UK) for additional quantitative analysis. The weighted mean difference (WMD) in each study was pooled with the random effect model. The differences in the surrogate WCE between the ethnic groups were assessed using the Z-test. A value of $p<0.05$ on the Z test was considered statistically significant.

Results

Methods of review studies

Table 1 shows that two studies samples were college-based,[15,16] one study was based on employees,[20] one study based on suspected hypertensives and normotensives,[13] and the rest were based on suspected hypertensive patients. The studies had varying aims relating to a range of cardiovascular risk factors. As a marker of ethnicity one study used country of origin,[18] and one used self-report,[15] while the others gave no information. Sample size varied widely. Three studies assessed men and women separately[13,14,16] the others combined them. Age range varied widely. In two UK studies, Afro-Caribbeans and South Asians were significantly younger than their White counterparts.[14,19] Five studies[14,15,17,19,20] provided data on BMI and all showed higher levels in people of African descent compared to whites, the differences being significantly higher in three studies.[15,19,20] South Asians had a lower BMI compared to Whites in both studies.[14,19] None of the studies reported a response rate. The average number of clinic visits before ABP monitoring differed, ranging from one visit[13,16] to three visits.[17,18,20] The number of readings per visits also varied widely between studies. In four studies office BP was measured by a nurse,[14,17,18,20], one study by a nurse or technician,[19] two studies by research associate,[15,16] and one study by a technician.[13] In one study,[15] office BP was measured in a laboratory, the rest in a clinic.

Mean White-coat effect

Table 2 shows that BP status and definition of daytime differed widely. Measurement techniques also differed. Two studies, [17,18] measured office BP by automated monitor (Sentron), the rest by mercury sphygmomanometer. ABP was monitored in two studies by intra-arterial technique,[14,19] and the rest by non-invasive technique. None of the studies showed significant differences between people of African origin and their white counterparts. In two US studies on normotensive college students, the mean systolic WCE was negative in both Whites and African Americans.[15,16] Also in two UK studies where Afro-Caribbeans were significantly younger, mean WCE was smaller compared to their White counterparts although the differences were not statistically significant.[14,19]

The pooled data are shown in figure 1 and 2. There were no significant differences in systolic and diastolic WCE between African origin populations and their White counterparts although the directions of the differences differ between the US and the UK studies non-invasive method studies. In the US studies for example, the weighted mean difference (WMD) in systolic WCE was 1.66 (95% CI, -0.83, 4.14) and diastolic WCE was 0.42 (95% CI = -1.54, 2.40). However, in the UK studies, the WMD in systolic WCE was -2.31 (95% CI = -11.15, 6.53) and diastolic WCE was – 0.42 (95% CI; -5.38, 4.53).

In both studies using intra-arterial[14,19] and non-invasive methods,[13,15,16,17,18,20] no significant differences were found although the WMD in both systolic and diastolic WCE were lower in intra-arterial technique studies compared to non-invasive studies. In two intra-arterial studies, the WMD in systolic WCE was –6.10 (95% CI = -13.12, 0.92) and the WMD in diastolic WCE was -2.68 (95% CI = -6.27, 0.91). For the six studies on non-invasive technique, WMD in systolic WCE was 0.98 (95% CI = -1.34, 3.30, $p = 0.41$; test for heterogeneity $X^2 = 4.81$; $p = 0.78$) and the WMD in diastolic WCE was 0.38 (95% CI, -1.31, 2.06, $P = 0.66$; test for heterogeneity $X^2 = 6.03$; $p = 0.54$).

In both studies of South Asians,[14,19] except females in Acharya *et al's* study,[14] the mean systolic and diastolic WCE was significantly smaller than whites. As shown in the pooled analysis (figure 2), the WMD for systolic and diastolic WCE was significantly lower in South Asians compared to whites.

Table 1 Contextual detail - publication, location, sampling frame, design, sample size, age, BMI, & clinic measurement details

First author surname & date of publication	a. Place, b. Study design, c. Basis of Sample	Ethnic group	n	Mean age (Years)	BMI	a. Average no. of clinic visits b. No. of readings/visit c. Person measuring BP d. Location of measurement
Gretler et al 1994 [13]	a. Chicago, USA b. Cross-sectional c. Hypertensives & Volunteers	W men B men W women B women	140 122 106 153	48.0 (1.3) 50.1 (1.3) 49.6 (1.5) 50.4 (1.3)	Not given (weight higher in blacks)	a. 1 visit b. 3 readings c. Technician d. Clinic
Acharya et al 1996[14]	a. Middlesex, UK b. Cross-sectional d. Hypertensive patients	W A-C SA	562 56 105	51 (11) 46 (9)*** 46 (9)***	26.7 (4.3) 27.0 (3.5) 25.6 (3.5)	a. 2 or more visits b. 2 or more readings c. Nurse d. Clinic
Shapiro et al 1996 [15]	a. Los Angeles, USA b. Cross-sectional c. College	W B	85 57	20.7 (2.4) 21.4 (2.7)	22.1 (2.3) 23.0 (3.3)*	a. 2 visits b. 5 readings c. Research associate d. Laboratory
Chase et al 1997 [16]	a. Denver, Colorado, USA b. Cross-sectional c. High Schools	W males A-A males W females A-A females	22 20 28 16	22.9 (0.8) 20.7 (1.0) 22.0 (0.7) 20.6 (0.8)	Not given	a. 1 visit b. 2 reading c. Research associate d. Clinic
Mayet et al 1998 [17]	a. London, UK b. Cross-sectional c. Hypertensive patients	W B	46 46	43 (2.0) 44 (1.9)	26.2 (0.8) 27.6 (0.7)	a. 3 visits b. ≥ 5 readings for the 3 visits c. Nurse d Clinic
Guzzetti et al 2000 [18]	a. London, UK b. Cross-sectional c. Hypertensive patients	W B	26 26	46 (2) 45 (2)	Not given (weight higher in whites)	a. 3 visits b. ≥ 5 readings for the 3 visits c. Nurse d Clinic
Khattar et al 2000 [19]	a. Harrow, UK b. Cohort study c. Hypertensives	W A-C SA	528 54 106	52.2 (10.9) 46.8 (9.1)*** 46.3 (9.1)***	26.9 (4.4) 27.3 (3.8)** 25.6 (3.6)**	a. 2 visits b. 2 or more c Nurse or technician d. Clinic
Steffen et al 2001 [20]	a. North Carolina, USA b. Cross-sectional c. Employees	W A-A	77 78	33 (6) 34 (6)	25.1 (2.8) 26.5 (3.7)**	a. 3 visits b. 3 readings c. Nurse d. Clinic

Abbreviations: W = White, B = Black, A-C = Afro-Caribbean, A-A = African American, SA = South Asian ABP = Ambulatory blood pressure, BP = Blood pressure, BMI = Body mass index, ***P*<0.01, ****P*<0.001, comparing each ethnic group against the white comparison group, values in parentheses are standard deviations

Discussion

Key findings

The WCE in people of African descent in both the UK and the USA was similar to that in White population while South Asians had a smaller WCE compared to Whites. It seems improbable that ethnic variations in BP, particularly, the raised levels in people of African descent, are attributable to WCE. The scientific literature on this topic is sparse with limitations in the data as discussed below. Nonetheless, this review provides important information on the primary question.

Limitations of the data under review

The number and size of studies is small particularly in South Asians. The diversity between African populations,[21,22] and South Asian populations[22] has long been emphasised but too often ignored. This was the case in the studies reviewed. Variations in protocols used for office BP measurement, ABP measurement techniques, definition of daytime, setting in which BP monitoring was carried out, and different study populations make interpretation difficult. For example, in six studies[13,15,16,17,18,20] participants' ABP was monitored using automated non-invasive devices designed by different manufacturers, which may yield different results.[23] The intensity of physical activity has been shown to have an effect on BP variability and this was not reported.[24] In two studies,[14,19] intra-arterial monitoring was used, which may lead to atypical results due to less physical activity. In three studies daytime BP was determined by a subject's diary record of being awake.[13,15,20] However, in others, daytime added up to six hours,[14] 16 hours[16,19] and 18 hours[17,18] of monitoring. With so much variation in types of study, comparisons between studies are difficult, but ethnic variations within studies are amenable to interpretation.

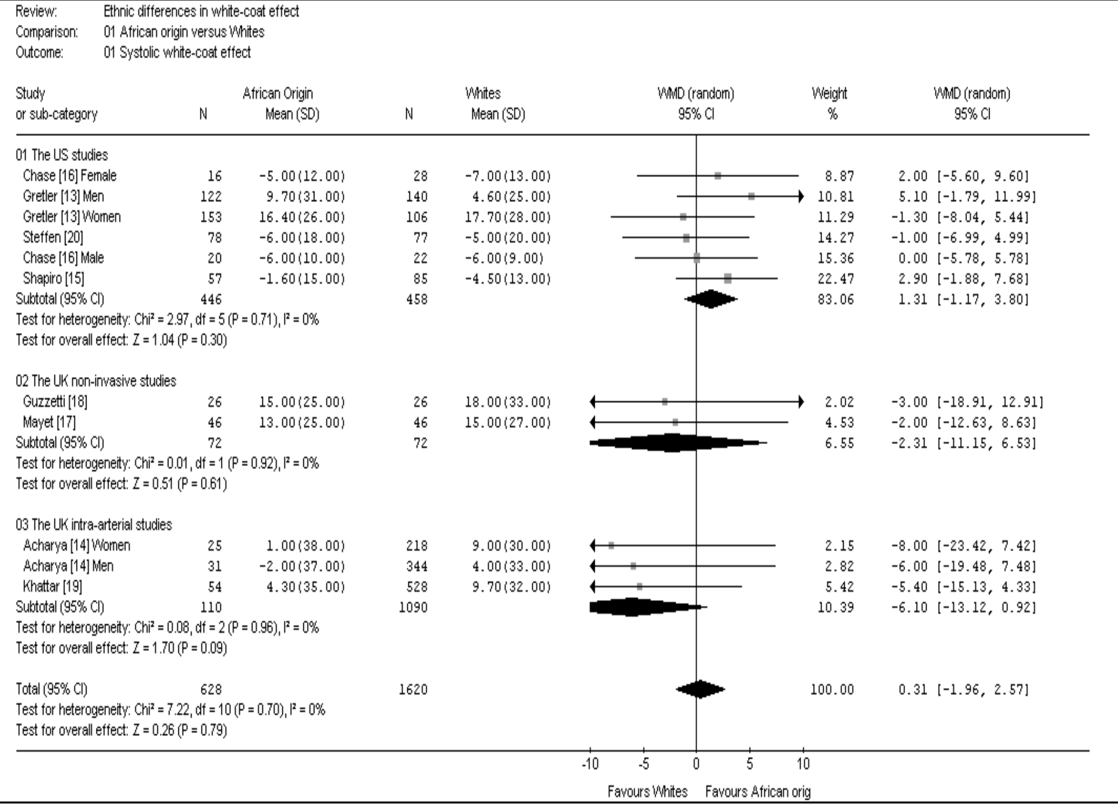
Table 2 BP status, daytime definitions, measurement techniques, mean clinic/baseline BP, daytime BP, and WCE by ethnic group

First author surname & date of publication	BP status	Daytime definitions	Measurement technique a. Office b. ABPM	Ethnic groups	Mean clinic/baseline BP		Mean daytime ambulatory BP		White-coat effect	
					SBP	DBP	SBP	DBP	SBP	DBP
Gretler et al 1994 [13]	Untreated hypertensive & normotensive	Participants' diary (Time not given)	a. Mercury Sphyg b. Non-invasive (Accutracker II)	W men	146.4 (20)	90.9 (11)	141.8 (14)	81.8 (9)	4.6 (25)	9.1 (14)
				B men	156.6 (24)*	98.2 (14)***	146.9 (19)¶	85.7 (11)¶	9.7 (31)	12.5 (18)
				W women	149.9 (24)	92.0 (12)	132.2 (14)	78.8 (10)	17.7 (28)	13.3 (16)
				B women	155.2 (21)	94.3 (10)	138.8 (16)¶	81.8 (10)¶	16.4 (26)	12.5 (14)
Acharya et al 1996 [14]	Hypertensives	1200-1800	a. Mercury Sphyg b. Intra-arterial	W men	170 (23)	103 (12)	166 (24)	97 (15)	4.0 (33)	6.0 (19)
				A-C men	174 (26)	106 (12)*	176 (27)***	103 (15)***	-2.0 (37)	3.0 (19)
				SA men	161 (16)**	101 (10)	165 (19)	100 (14)	-4.0 (25)**	-1.0 (17)*
				W women	173 (22)	101 (12)	164 (20)	95 (13)	9.0 (30)	6.0 (18)
				A-C women	167 (30)	103 (13)*	166 (23)**	101 (13)**	1.0 (38)	2.0 (18)
				SA women	158 (17)**	101 (10)	161 (23)	98 (14)	-3.0 (29)	3.0 (17)
Shapiro et al 1996 [15]	Normotensive	Participants' diary (Time not given)	a. Mercury Sphyg b. Non-invasive (Accuracker II)	W	116.9 (9.3)	68.2 (7.3)	121.4 (9.7)	68.2 (5.8)	-4.5 (13)	0.0 (9)
				B	121.5 (11.2)***	73.0 (9.6)	123.1 (10.1)	71.1 (7.0)	-1.6 (15)	1.9 (12)
Chase et al 1997 [16]	Normotensive	0600-2200	a. Mercury Sphyg b. Non-invasive (SpaceLabs 90207)	W male	119 (7)	78 (7)	125 (5)	74 (6)	-6.0 (9)	4.0 (9)
				A-A male	121 (7)	77 (11)	127 (7)	77 (8)	-6.0 (10)	0.0 (14)
				W female	111 (11)	71 (8)	118 (6)	74 (6)	-7.0 (13)	-3.0 (10)
				A-A female	113 (9)	71 (8)	118 (8)	73 (6)	-5.0 (12)	-2.0 (10)
Mayet et al 1998 [17]	Previously untreated hypertensive	0600-2400	a. Automated (Sentron) b. Non-invasive (SpaceLabs 90207)	W	164 (22)	96 (12)	149 (15)	95 (10)	15.0 (27)	1.0 (16)
				B	158 (20)	96 (11)	145 (15)	95 (12)	13.0 (25)	1.0 (16)
Guzzetti et al 2000 [18]	Essential hypertensive	0600-2400	a. Automated (Sentron) b. Non-invasive (SpaceLabs 90207)	W	163 (25)	96 (10)	145 (20)	93 (10)	18.0 (33)	3.0 (14)
				B	162 (20)	99 (10)	147 (15)	97 (10)	15.0 (25)	2.0 (14)
Khattar et al 2000 [19]	Hypertensive	0600-2200	a. Mercury Sphyg b. Intra-arterial	W	173.5 (23.2)	103.0 (12.9)	163.8 (21.9)	95.0 (13.3)	9.7 (32)	8.0 (19)
				A-C	173.4 (25.7)	106.1 (13.0)	169.1 (23.9)	100.0 (12.9)***	4.3 (35)	6.1 (18)
				SA	161.3 (19.9)***	101.3 (12.5)	162.0 (19.8)	98.1 (13.4)	-0.7 (28)**	3.0 (18)**
Steffen et al 2001 [20]	Normotensive and hypertensive	Participants' diary (Time not given)	a. Mercury Sphyg b. Non-invasive (Accuracker II)	W	118 (14)	78 (10)	123 (14)	76 (9)	-5.0 (20)	2.0 (13)
				A-A	119 (13)	78 (10)	125 (13)	78 (10)	-6.0 (18)	0.0 (14)

Abbreviations: W = White, B = Black, A-C = Afro-Caribbean, A-A = African American, SA = South Asian, BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, WCE = White-coat effect, Sphyg = Sphygmomanometer *P<0.05, **P<0.01, ***P<0.001, comparing each ethnic

Figure: Weighted mean difference in SBP and DBP WCE between African origin and White people in the USA and UK studies

Systolic



Diastolic

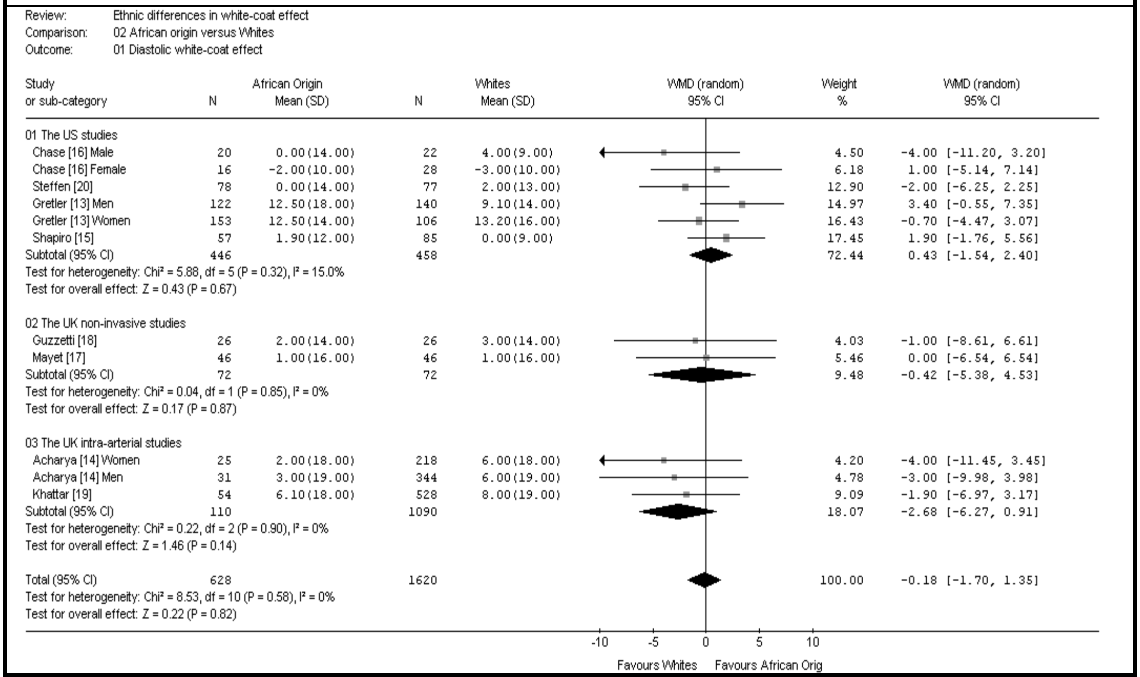
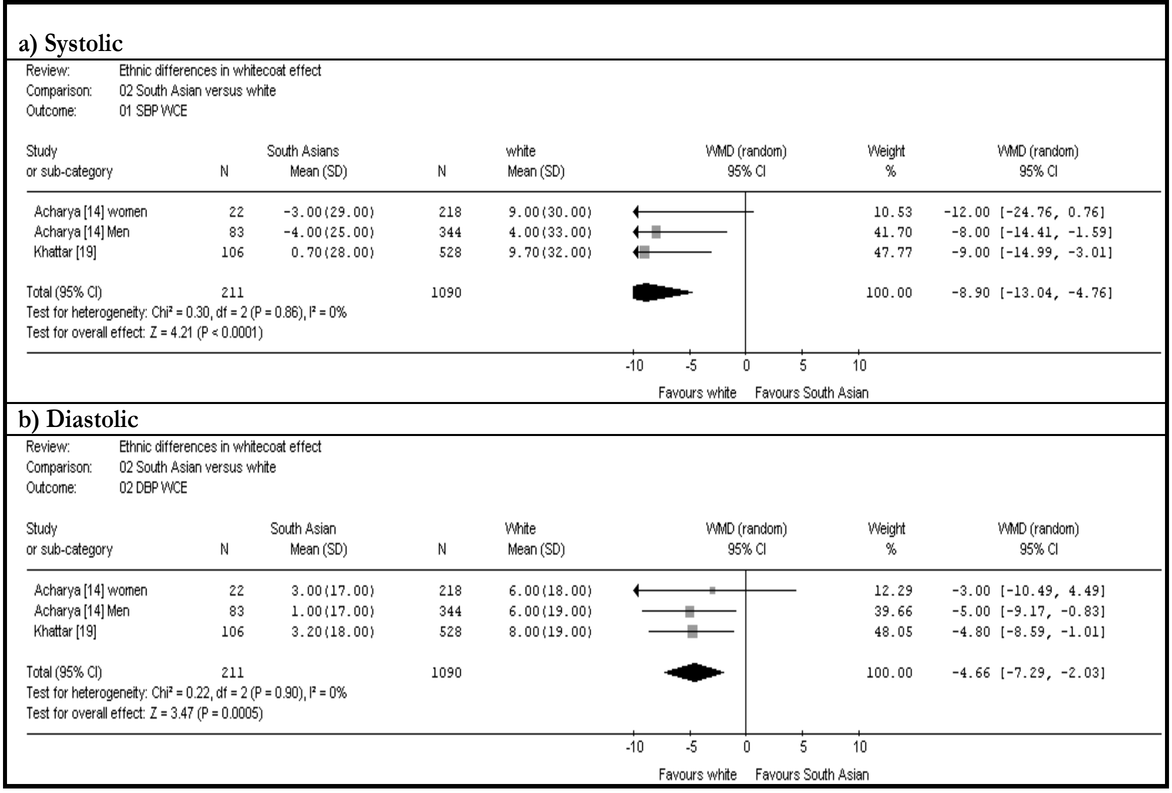


Figure 2: WMD in SBP and DBP white-coat effect between South Asian and White people in UK studies



Although the estimation of the WCE from the difference between clinic and daytime ABP is widely used as a surrogate measure,[9,11,12] it may not reflect the true increase in BP elicited by the clinic visit.[25] Parati and colleagues did not find any relationship between the WCE determined on a beat-to-beat basis with the Finapres method from before and during the visit, and the difference between the clinic BP and daytime ABP.[26] Other methods to access WCE that have been used include the difference between clinic and home BP.[25] However, data using these methods by ethnic group are currently unavailable. Nonetheless, differences in methods in the quantification of WCE are also likely to make comparisons between studies difficult. International standardisation of indirect quantification of WCE is long overdue. Owen and colleagues suggest that the WCE could be more safely quantified as a significant increase in the ambulatory BP values obtained during the first clinic visit and/or of last hour of the two 24 hour recordings obtained when the subject is in a clinic environment, as compared to the average BP of the remaining part of the daytime period.[27] Despite these limitations the review provided valuable information on the primary question.

Discussion of the key findings

The finding of similar WCE in people of African and a lower WCE in South Asian descent compared to Whites is surprising given that WCE is the result of a transient pressor response triggered by an alerting reaction in the clinical environment.[7] As the ethnic minority groups have higher levels of some indicators of stress,[28,29] it might be expected that their alerting reaction is correspondingly higher in a clinical environment. However, South Asian hypertensives in both studies showed a 'reverse' systolic WCE,[14,19] a phenomenon Kumpusalo and others refer to as 'relaxing reaction in WCE'.[30] Afro-Caribbean hypertensive men also had a 'reversed' systolic WCE in Acharya *et al's* study.[14] The cause and implications of this 'reversed' WCE is not well elucidated,[31] although others suggest that it might be associated with increased cardiovascular risk.[32,33] In another study that was excluded because of lack of clarity in definition of ethnic groupings, WCE was significantly higher in Caucasians than non-Caucasians ($P<0.001$).[34] There is evidence that suggests a positive correlation between WCE and advancing age[34,35] and BMI.[34] In South Asians, these factors are clearly applied. In Acharya *et al*'s[14] and Khattar *et al's*[19] studies, South Asians were significantly younger and had a lower BMI possibly explaining the smaller WCE compared to their White counterparts. However, in people of African descent, higher BMI did not correspond to a greater WCE. For example, in Mayet *et al*'s[17] and Khattar *et al*'s[19] studies, Blacks had a higher BMI but a lower WCE compared to white counterparts.

Evidence suggests that WCE is greater in essential hypertensive subjects than normotensive subjects.[34,35] Our findings are in agreement with this evidence. In two studies on normotensive healthy college students, the systolic WCE in both African American and White American students showed a 'reversed' WCE[15,16] compared to essential hypertensive subjects with a greater WCE in most studies.

In conclusion, the finding of no excess of WCE between people of African descent and Whites may imply that the higher BP in older people of African descent could not be attributed to the white-coat phenomenon. In contrast, the slightly lower clinic BP in some South Asian populations such as Pakistanis and Bangladeshis [2] might be partly caused by a low WCE. More work is needed on this topic among ethnic minority groups. International standardisation of indirect quantification of WCE is also needed.

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Does nocturnal blood pressure fall in people of African and South Asian descent differ from that in European white populations? A systematic review and meta-analysis

Charles Agyemang[1]

Raj Bhopal[2]

Marc Bruijnzeels[1]

W Ken Redekop[1]

[1]Institute of Health Policy and Management, Erasmus Medical Centre, Rotterdam, The Netherlands
[2]Public Health Sciences, University of Edinburgh College of Medicine and Veterinary Medicine, Teviot Place, Edinburgh, UK

Published in *Journal of Hypertension* 2005; **23**:913-20.

6

Abstract

Objective: To assess whether nocturnal blood pressure fall in people of African (Black) and South Asian descent differs from that of the European origin white populations (White).

Methods: A systematic literature review was carried out using Medline 1966–2003 and Embase 1980–2003, and citations from references. The meta-analysis was performed using Cochrane review manager software (RevMan version 4.2; The Cochrane Collaboration, Oxford, UK).

Results: Seventeen studies were identified; 11 studies from the USA, one from the USA and Canada, and six studies from the United Kingdom. The mean percentage systolic blood pressure (SBP) nocturnal fall was below 10% (non-dipping) in 10 of 17 studies (59%) and the diastolic blood pressure (DBP) nocturnal fall was below 10% in four of 16 studies (25%) in Blacks compared with four of 17 studies (24%) in SBP and none in DBP nocturnal falls in Whites. Compared with Whites, Blacks had a significantly lower mean percentage nocturnal fall; the overall weighted mean difference in SBP was -3.07 (95% confidence interval, -3.81, -2.33; $P < 0.00001$) and in DBP was -2.98 (95% confidence interval, -3.97, -2.00; $P < 0.00001$). Two studies on South Asians showed a higher SBP but a similar mean DBP nocturnal fall compared with Whites.

Conclusion: Smaller nocturnal blood pressure falls and a higher prevalence of non-dipping may contribute to the higher levels of hypertension complications seen in Black people. No such phenomenon was seen in South Asians but more research is needed to explore their higher stroke mortality.

Keywords: ethnic variations; Blacks; South Asian; nocturnal blood pressure fall

Introduction

Recent systematic reviews on adult populations in the United Kingdom have shown that, compared with the White, European origin populations (White), the mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) are similar in people of South Asian descent (Indians, Pakistanis and Bangladeshis)[1] but are higher in those of African descent (Black)[2]. However, in younger adults and in children there were similarities in mean SBP and DBP across all ethnic groups[2,3]. In comparison with White populations, the higher blood pressure (BP) in older Afro-Caribbean people in the United Kingdom is consistent with higher BP levels in African-Americans in the USA, but similar BP levels in the younger age groups in the United Kingdom contrast with the USA findings where the BP level is comparatively high in African-Americans in all ages[4]. The reasons for these differences are not clear. Evidence also indicates that hypertension complications seen in Blacks are not explained entirely by ethnic differences in casual BP levels[5]. The nocturnal BP fall (daytime BP minus night-time BP) may be an important determinant of hypertensive cardiovascular complications, especially in those individuals in whom BP fails to fall by 10% (non-dippers)[6]. A diminished nocturnal decline in BP has independently been associated with increased stroke[7–9], left ventricular hypertrophy[6,10] and progression of renal damage[11]. In both the USA and Europe, there is a perception that nocturnal BP fall is comparatively low in Blacks compared with Whites. However, studies in both regions, particularly in the United Kingdom, have not always shown consistent results. Little is known about the nocturnal BP fall in South Asian descent populations. In this meta-analysis, we investigated whether nocturnal BP fall patterns in Black and South Asian people differ from those of the White populations.

Methods

Search strategy

EMBASE and MEDLINE searches identified papers published from 1980 to 2003 and from 1966 to 2003, respectively. Medical Subject Heading 'Asians' or 'South Asians' or 'Caribbean and Asian' or 'Indians', or 'Pakistanis', or 'Bangladeshis', or 'Africans' or 'African Americans' or 'black Americans' or 'African Caribbean', or 'blacks', or 'ethnic minority population' or 'racial stock' were combined with 'nocturnal BP fall', 'ABP', 'ABP monitoring' 'ambulatory intra-arterial BP', 'diurnal BP' and 'circadian BP'. Personal files were checked and reference lists in the papers were examined.

Inclusion criteria

Studies were included in the review if they met the following predefined criteria: (1) they reported mean nocturnal BP fall and/or percentage nocturnal fall, and daytime and night-time 24-h systolic or diastolic ambulatory blood pressure (ABP) (either invasive and non-invasive techniques) on samples of adults of Black and South Asian descent populations in comparison with a White or general population; (2) the studies on non-invasive techniques were included if the devices used to measure ABP have been validated using established protocols of the European Hypertension

Society or British Hypertension Society or Association for the Advancement of Medical Instruments; and (3) the average daytime ABP was based on >= 10 readings and night-time average ABP on >= 5 readings.

Study selection and data extraction

Seventeen studies met the inclusion criteria[12–28], six from the United Kingdom[12,16,18,22,25,26] and 11 from the USA[13–15,17,19–21,23,24,27,28] (one comparing a Canadian White group with a US Black group[27]). One study was a clinical trial,[23] one reported cross-sectional data from a cohort design[26] and the rest were cross-sectional. With a few exceptions[14,16,18,22,23,27] we calculated the mean systolic and diastolic nocturnal fall by subtracting the mean night-time ABP from the mean daytime ABP, and derived the percentage fall and estimated standard deviations[6]. We used Cochrane review manager software (RevMan version 4.2; The Cochrane Collaboration, Oxford, UK) for additional quantitative analysis. The weighted mean difference (WMD) in each study was pooled with the random effect model. The mean percentage nocturnal fall differences between the ethnic groups were assessed using the Z-test.

Results

Methods of review studies

Table 1 shows that six studies were based on non-patient community samples[15,16,20,21,24,28] and the rest were based on clinically hypertensive or suspected hypertensive patients. Only two studies included South Asians.[18,22] The studies had different aims relating to a range of cardiovascular risk factors. Only five studies reported indicators of ethnicity[12,15,16,20,25] — country of origin,[12,25] appearance and parental origin,[16] and self-determined ethnicity.[15,20] Three studies combined Afro-Caribbeans and West Africans as one ethnic group.[16,22,25] Six studies reported on normotensive subjects,[13,15,16,20,21,24] one reported on normotensive and hypertensive subjects combined,[28] and the rest were based on hypertensive subjects. Sample size varied widely. With four exceptions,[17–19,21] all the results were based on men and women combined. The age range varied widely. Chaturvedi et al. had a 58% response rate[16] but the rest of the studies did not give response rates. One study compared Canadian white with US African-American populations. [27] Nine studies[15,18,20,22–24,26–28] reported the body mass index (BMI) and all showed a higher level in Blacks compared with Whites, the differences being significantly higher in five studies[20,23,24,26,27]. South Asians had a lower BMI than Whites in both relevant studies.[18,26]

Mean nocturnal BP fall

Table 2 shows that the definitions of daytime and night-time periods differed widely. In three UK studies, participants' ABP was assessed by an intra-arterial technique,[12,18,26] and the rest by non-invasive techniques. The ABP monitoring devices also differed between studies. Three studies[17,18,27] showed a significantly higher daytime SBP and three studies[17,18,26] showed a significantly higher DBP in Blacks compared with Whites. For night-time BP, eight studies showed a significantly higher SBP[13,14,17,18,20,24,27,28] and all except five studies[12,15,21–23] showed significantly higher DBP in Blacks compared with Whites.

African descent

Mean percentage BP nocturnal fall (non-dipping) and pooled analysis

The mean percentage SBP and DBP nocturnal fall varied widely and mostly was lower in Blacks compared with Whites. In nine studies[13–15,19,21–23,25,27] and in Black women in Gretler et al[17] the mean percentage SBP nocturnal fall was below 10% in Blacks, while in only three studies[14,19,23] and in males in Chase et al.[21] it was below 10% in Whites. In four studies[22,23,25,27] the mean percentage DBP nocturnal fall was below 10% in Blacks, while none was below 10% in White subjects. In three UK studies on intra-arterial techniques, the derived percentage nocturnal BP falls were above 10% in all ethnic groups[12,18,26].

In all seven community-based studies[13,15,16,20,21,24,28], including the six studies[13,15,16,20,21,24] that provided data on non-patient normotensive subjects, the mean nocturnal BP fall was lower in Blacks except in Chase et al.'s study.[21] In three studies on normotensives[13,15,21] the mean percentage nocturnal SBP fall was below 10% in Blacks, while only White males in Chase et al.[21] had such a value.

Results of the pooled analysis are shown in Figures 1 and 2. Figure 1a,b show WMDs in the SBP and DBP nocturnal fall between Blacks and Whites. The overall effect for SBP and DBP percentage nocturnal falls was significantly lower in Blacks compared with their White counterparts in both the UK and USA studies. In the USA, the overall WMD in SBP was -3.46 [95% confidence interval (CI), -4.37, -2.55; $p < 0.00001$] and in DBP was -3.38 (95% CI, -4.59, -2.17; $p < 0.00001$), and tests for heterogeneity were not significant. The UK studies using intra-arterial methods showed different results than those using non-invasive methods. As Figure 1a,b shows, none of the studies using intra-arterial methods found significant differences between the two groups. The *Z* score for the overall effect for SBP and DBP nocturnal fall was similar between the groups. However, the two UK studies using non-invasive methods showed a significantly lower overall effect for nocturnal BP falls in Blacks compared with Whites. Both normotensive and hypertensive Black subjects showed lower percentage nocturnal fall compared with their White counterparts. In normotensives, the WMD in SPB nocturnal fall was -2.71 (95% CI, -4.49, -0.90; $p = 0.003$; test for heterogeneity, $\chi^2 = 3.75$, $p = 0.71$) and in DBP nocturnal fall was -2.83 (95% CI, -5.32, -0.34; $p < 0.03$; test for heterogeneity, $\chi^2 = 1.24$, $p = 0.94$). For hypertensives, the WMD in SBP nocturnal fall was -3.12 (95% CI, -4.08, -2.15; $p < 00001$; test for heterogeneity, $\chi^2 = 15.35$, $p = 0.35$) and the WMD for DBP nocturnal fall was -3.21 (95% CI, -4.41, -2.02, $P < 0.00001$; test for heterogeneity, $\chi^2 = 2.17$, $p = 0.43$).

South Asian descent

In both studies of South Asians [18,25] the mean percentage nocturnal fall was above 10% in both groups. The pooled analysis in Figure 2 shows that the SBP nocturnal fall was significantly higher in South Asians than in Whites. The WMD in SBP nocturnal fall was 1.57 (95% CI, 0.37, 2.77; $P < 0.01$); the overall effect for DBP nocturnal fall was similar between the groups.

Discussion

Key findings

Black people, both in the USA and the United Kingdom, have lower mean SBP and DBP nocturnal falls, and a higher prevalence of 'non-dipping' compared with their White counterparts. The percentage nocturnal fall by intra-arterial methods showed a smaller and statistically non-significant ethnic difference than non-invasive methods in UK studies. On the basis of only two studies South Asians had a higher SBP nocturnal fall but a similar DBP nocturnal fall compared with Whites.

Limitations of the data reviewed

Variations in methods of measurement techniques, definitions of day and night, and settings in which BP monitoring was carried out preclude easy comparisons between studies. For example, in most studies the participants' ABP was monitored using automated non-invasive devices designed by different manufacturers, which may yield different results[29]. In three studies[12,18,26] intra-arterial monitoring was used, which may lead to less artificially induced increase in ABP due to less physical activity. There is no agreement on daytime and night-time BP definitions, although the recent recommendations of the British Hypertension Society suggest dividing the 24-h into day (beginning with the first entry on the diary card) and night (beginning with the last entry), or a fixed time method.[30] In five studies, 24-h daytime and night-time BP was determined by the subject's diary record of being awake and asleep,[12,17,20,24,28] whereas in others daytime and night-time was determined by the researchers with different fixed time intervals. Differences in times that subjects woke up or went to bed may also affect the comparability of the results. In Ituarte et al.'s study,[24] Black subjects got out of bed more often than their White counterparts (87.5 versus 12.5%, $p < 0.05$). Blacks also reported significantly more sleep disturbances than Whites in this study[24]. The intensity of physical activity has been shown to have a profound effect on BP variability.[31] Differences in daytime activities and settings where ABP monitoring was conducted are likely to affect the study findings. Evidence also indicates that BP dipping at night is poorly reproducible.[32]

Table 1 Contextual details-publication, location, design, sampling frame, sample size, age and BMI

First author surname & publication date	a. Place, b. Study design, c. Basis of sample	Indicator of ethnicity	BP status	Ethnic group	n	Age (years)	BMI
Rowlands et al 1982 [12]	a. Birmingham, UK b. Cross-sectional c. Hospital patients	Country of origin	Hypertensives	W B	16 16	42 (11) 42 (10)	Not given (weight significantly higher in blacks)
James et al 1991[13]	a. New York, USA b. Cross-sectional c. Hospital employees	Not given	Normotensives	W B	27 83	29.4 (6.7) 31.0 (6.7)	Not given (weight higher in blacks)
Murphy et al 1991[14]	a. Chicago, USA b. Cross-sectional c. Hypertensive patients	Not given	Hypertensives	W B	37 44	46 (16) 45 (15)	Not given
Fumo et al 1992[15]	a. Chicago, USA b. Cross sectional c. Volunteers	Self-report	Normotensives	W A-A	22 22	37 (12) 37 (13)	24.0 (2.8) 26.6 (5.3)
Chaturvedi et al, 1993[16]	a. London, UK b. Cross-sectional c. Six GP lists	Appearance and parental origin	Normotensive, hypertensive, untreated	W A-C	152 167	40-64	Not given
Gretler et al 1994[17]	a. Chicago, USA b. Cross-sectional c. Hypertensives & Volunteers	Not given	Hypertensives	W men W women B men B women	140 106 122 153	48.0 (1.3) 49.6 (1.5) 50.1 (1.3) 50.4 (1.3)	Not given (weight significantly higher in blacks)
Acharya et al 1996 [18]	a. Middlesex, UK b. Cross-sectional c. Hypertensive patients	Not given	Hypertensives	W A-C S-A	562 56 105	51 (11) 46 (9)*** 46 (9)***	26.7 (4.3) 27.0 (3.5) 25.6 (3.5)
Hebert et al 1996[19]	a. Columbus, USA b. Cross-sectional study c. Hypertensive patients	Not given	Hypertensives	W male W female B male B female	40 32 20 42	50.4 (2.36) 53.9 (2.79) 51.7 (1.93) 51.3 (2.32)	Not given (weight higher in blacks)
Shapiro et al 1996[20]	a. Los Angeles, USA b. Cross-sectional c. College	Self-report	Normotensives	W B	85 57	20.7 (2.4) 21.4 (2.7)	22.1 (2.3) 23.0 (3.3)*
Chase et al 1997[21]	a. Colorado, USA b. Cross-sectional c. High schools & colleges	Not given	Normotensives	W male W female A-A male A-A female	22 28 20 16	22.9 (0.80) 22.0 (0.70) 20.7 (1.03) 20.6 (0.84)	Not given
Mayet et al 1998[22]	a. London, UK b. Cross sectional c. Hypertensive patients	Not given	Hypertensives	W B	46 46	43 (2.0) 44 (1.9)	26.2 (0.8) 27.6 (0.7)
Olutade et al 1998[23]	a. Atlanta, USA b. Clinical trial c. Hypertensive patients	Not given	Hypertensives	W B	39 34	52 (12) 54 (11)	26.2 (4.0) 29.4 (5.1)**
Ituarte et al 1999[24]	a. California, USA b. Cross sectional c. Educated employees	Not given	Normotensives	W B	60 60	31.9 37.8***	24.7 27.5***
Guzzetti et al 2000[25]	a. London, UK b. Cross sectional c. Hypertensive patients	Country of origin	Hypertensives	W B	26 26	46 (2) 45 (2)	Not given (weight higher in whites)
Khattar et al 2000[26]	a. Harrow, UK b. Cohort study c. Hypertensive patients	Not given	Hypertensives	W A-C S-A	528 54 106	52.2 (10.9) 46.8 (9.1)*** 46.3 (9.1)***	26.9 (4.4) 27.3 (3.8)** 25.6 (3.6)**
EL-Gharbawy et al 2001[27]	a. Montreal & Wisconsin b. Cross-sectional c. Hypertensive patients	Not given	Hypertensives	W B	82 54	47 (1) 45 (1)	27 (1) 31 (1)***
Sherwood et al 2002[28]	a. North Carolina, USA b. Cross-sectional c. Employees	Not given	Normotensive & Hypertensives	W A-A	69 59	25-45	25.5 (2) 26.1 (3.4)

Abbreviations: W = White, B = Black, A-C = African Caribbean, A-A = African American, SA = South Asian, *P<0.05, ***P<0.001, comparing each minority group with White group; values in parentheses are standard deviations

Table 2 Day and night definition, measurement technique, mean daytime BP, nighttime BP, and nocturnal fall by ethnic group

First author surname & publication date	Day and night definitions	Measurement technique	Ethnic group	Mean daytime BP		Mean night-time BP		% Nocturnal fall	
				SBP	DBP	SBP	DBP	SBP	DBP
Rowlands et al 1982 [12]	Participants' diary (Time not given)	Intra-arterial	W	138 (14)	86 (11)	118 (18)	74 (9)	14.5 (17)	14.0 (17)
			B	134 (15)	86 (11)	113 (17)	72 (11)	15.7 (17)	16.3 (18)
James et al 1991[13]	Work: 1100-1500	Non-invasive (SpaceLabs 5200 or 90202)	W	119 (9)	76 (7)	104 (7)	60 (6)	12.6 (10)	21.0 (12)
	Sleep: 2200-0600		B	120 (11)	78 (7)	109 (10)**	65 (9)**	9.2 (12)	16.7 (15)
Murphy et al 1991[14]	Day: 0600-2259	Non-invasive (Accutracker)	W	143 (12)	83 (8)	129 (10)	69	9.8 (7)	16.9 (10)
	Night: 2300-0559		B	143 (13)	85 (10)	135 (6)**	76**	6.0 (6) **	10.6 (12)**
Fumo et al 1992[15]	Day: 0600-2259	Non-invasive (SpaceLabs 9202)	W	127 (13)	75 (8)	109 (11)	61 (7)	14.2 (13)	18.7 (14)
	Night: 2300-0559		B	128 (12)	76 (8)	117 (13)	66 (10)	8.6 (14)	13.1 (17)
Chaturvedi et al, 1993[16]	Day: 0900-1100	Non-invasive (Tokeda TM2420)	E normotensive	126 (22)	Not given	104(17)	Not given	17.5 (18)	Not given
	Night: 0300-0500		A-C normotensive	125(26)		108(16)*		12.6 (21)	
			E hypertensive	150(29)		122(21)		17.3 (20)	
			A-C hypertensive	146(33)		121(20)		15.8 (23)	
			E untreated	133(25)		109(13)		18.0 (19)	
			A-C untreated	131(26)		112(20)		13.5 (20)	
Gretler et al 1994[17]	Participants' diary (Time not given)	Non-invasive (Accutracker II)	W men	141.8 (1.2)	81.8 (0.8)	122.6 (1.2)	68.3 (0.8)	13.5 (14)	16.5 (16)
			B men	146.9 (1.7)¶	85.7 (1.0)¶	131.4 (1.9)¶	74.0 (1.1)¶	10.6 (19)	13.7 (19)
			W women	132.2 (1.4)	78.8(1.08)	115.6 (1.6)	64.9 (1.0)	12.6 (17)	17.6 (19)
			B women	138.8 (1.3)¶	81.8(0.8)¶	127.2 (1.5)¶	70.9 (0.9)¶	7.1 (18)**	13.3 (18)
Acharya et al 1996[18]	Day: 1200-1800	Intra-arterial	W men	166 (24)	97 (15)	139 (26)	78 (15)	16.3 (11)	19.6 (13)
	Night: 2400-0600		A-C men	176 (27)**	103 (15)***	148 (27)***	85 (16)***	15.9 (11)	17.5 (13)
			S-A men	165 (19)	100 (14)	135 (22)	80 (14)*	18.2 (9)	20.0 (11)
			W women	164 (20)	95 (13)	131 (23)	72 (15)	19.5 (10)	24.2 (12)
			A-C women	166 (23)	101 (13)***	137 (22)***	80 (14)***	17.5 (11)	20.8 (11)
			S-A women	161 (23)	98 (14)	131 (20)	77 (15)*	18.6 (13)	21.4 (14)
Hebert et al 1996[19]	Day: 0600-2200	Non-invasive (SpaceLabs 90207)	W men	144 (2)	90 (1)	128 (2)	76 (2)	9.9 (12)	15.6 (16)
	Night: 0100-0500		B men	143 (2)	92 (2)	130 (4)	82 (2)	9.1 (14)	10.9 (14)
			W women	139 (2)	85 (2)	129 (4)	73 (2)	7.2 (18)	14.1 (19)
			B women	143 (2)	89 (2)	131 (3)	79 (2)**	8.4 (16)	11.2 (21)
Shapiro et al 1996 [20]	Participants' diary (Time not given)	Non-invasive (Accutracker II)	W	121.4 (9.7)	68.2 (5.8)	105.4 (8.9)	55.2 (5.7)	13.2 (11)	19.1 (12)
			B	123.1 (10.1)	71.1 (7.0)	109.0 (6.5)*	59.4(6.5)***	11.5 (10)	16.5 (14)
Chase et al 1997[21]	Day: 0600-2200	Noninvasive, (SpaceLabs 90207)	W male	125 (5)	74 (6)	114 (8)	63 (7)	8.8 (12)	14.9 (13)
	Night: 2200-0600		A-A male	127 (7)	77 (8)	115 (8)	65 (8)	9.4 (14)	15.6 (15)
			W female	118 (6)	74 (6)	105 (7)	59 (6)	11.0 (18)	20.3 (12)
			A-A female	118 (8)	73 (6)	108 (9)	60 (7)	8.4 (16)	17.8 (13)

Abbreviations: W = White, B = Black, E= European; A-C = Afro-Caribbean; A-A = African American, SA = South Asian; BP = Blood pressure; SBP = Systolic blood pressure; DBP = Diastolic blood pressure; **P*<0.05, ***P*<0.01, ****P*<0.001 comparing each ethnic group the white group; ¶ stated significant but level not given; Values in parentheses are standard deviations

Table 2 continued

First author surname & publication date	Day and night definitions	Measurement technique	Ethnic group	Mean daytime BP		Mean night-time BP		% Nocturnal fall	
				SBP	DBP	SBP	DBP	SBP	DBP
Mayet et al 1998[22]	Day: 0600-2400	Non-invasive	W	149 (2.2)	95 (1.5)	132 (3.2)	81 (2.0)	10.7 (8)	13.7 (9)
	Night: 2400-0600	(SpaceLabs 90207)	B	145 (2.2)	95 (1.7)	136 (2.6)	86 (1.7)	5.5 (7)***	8.4 (9)**
Olutade et al 1998[23]	24 hours but time	Non-invasive	W	149 (14)	95 (9)	135 (14)	83 (9)	9.4 (5)	13.7 (5)
	not given	(Spacelabs 90207)	A-A	150 (12)	96 (7)	141 (13)	87 (80	6.0 (5)**	9.4 (7)**
Ituarte et al 1999 [24]	Electronic diary	Non-invasive	W	117.9 (6.7)	75.4 (6.0)	98.9 (9.0)	59.6 (9.0)	16.2 (10)	20.9 (14)
	(Time not given)	(Accutracker DX)	B	121.3 (11.4)	78.8 (7.4)	106.3 (11)**	64.5 (7.0)**	12.3 (13)**	18.2 (13)
Guzzetti et al 2000 [25]	Day: 0600-2400	Non-invasive	W	145 (4)	93 (2)	128 (5)	78(2)	11.2 (23)	16.1 (16)
	Night: 0000-0600	(SpaceLabs 90207)	B	147 (3)	97(2)	139 (4)	89 (2)*	5.4 (17)	8.2 (15)
Khattar et al 2000[26]	Day: 0600-2200	Intra-arterial	W	163.8 (21.9)	95.0(13.3)	141.4 (24.3)	79.0 (14.9)	13.7 (7)	16.8 (9)
	Night: 2200-0600		A-C	169.1 (23.9)	100.0(12.9)***	147.3 (24.6)	84.8 (14.2)**	12.9 (7)	16.8 (9)
			S-A	162.0 (19.8)	98.1 (13.4)	137.3 (21.2)	81.4 (14.0)	15.3 (7)**	15.5 (8)
EL-Gharbawy et al, 2001[27]	Day: 0500-1100	Non-invasive	W	136 (2)	84 (1)	123 (2)	75 (2)	10.3 (6)	10.7 (10)
	Night: 1100-0500	(Accutracker II)	B	143 (2)**	86 (1)	135 (2)***	80 (1)**	5.6 (6)***	7.0 (11)**
Sherwood et al 2002[28]	Participants' dairy	Non-invasive	W	124 (13)	76 (9)	106 (13)	63 (9)	14.5 (6)	17.1 (7)
		(Accutracker II)	A-A	126 (13)	79 (10)	112 (14)*	67 (11)*	11.1 (6)	15.1 (8)

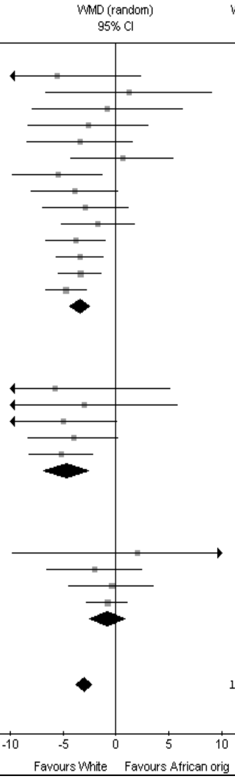
Abbreviations: W = White, B = Black, A-A= African American; A-C= Afro-Caribbean, BP = Blood pressure; SBP = Systolic blood pressure; DBP = Diastolic blood pressure; *P<0.05,**P<0.01, ***P<0.001, comparing each ethnic group with the white group; Values in parentheses are standard deviations.

Fig. 1 WMD in SBP & DBP percentage nocturnal fall between African and White people in the USA and UK

a) Systolic

Review: Nocturnal Blood Pressure Fall
Comparison: 01 African origin versus white in Systolic Nocturnal Fall
Outcome: 01 Systolic Nocturnal Fall

Study or sub-category	African origin N	African origin Mean (SD)	White N	White Mean (SD)	Weight %	WMD (random) 95% CI
01 American studies						
Fumo [15]	22	8.60(14.00)	22	14.20(13.00)	0.87	-5.60 [-13.58, 2.38]
Hebert [19] Women	42	8.40(16.00)	32	7.20(18.00)	0.89	1.20 [-6.69, 9.09]
Hebert [19] Men	20	9.10(14.00)	40	9.90(12.00)	1.07	-0.80 [-7.97, 6.37]
Chase [21] Female	16	8.40(10.00)	28	11.00(8.00)	1.68	-2.60 [-8.33, 3.13]
James [13]	27	9.20(12.00)	83	12.60(10.00)	2.20	-3.40 [-8.41, 1.61]
Chase [21] Males	20	9.40(8.00)	22	8.80(8.00)	2.35	0.60 [-4.24, 5.44]
Gretler [17] Women	153	7.10(18.00)	106	12.60(17.00)	2.97	-5.50 [-9.81, -1.19]
Ituarte [24]	59	12.30(13.00)	60	16.20(10.00)	3.17	-3.90 [-8.07, 0.27]
Gretler [17] Men	122	10.60(19.00)	140	13.50(14.00)	3.30	-2.90 [-6.99, 1.19]
Shapiro [20]]	57	11.50(10.00)	85	13.20(11.00)	4.52	-1.70 [-5.19, 1.79]
Murphy [14]	44	6.00(6.00)	37	9.80(7.00)	6.71	-3.80 [-6.67, -0.93]
Olutade [23]	34	6.00(5.00)	39	9.40(5.00)	10.44	-3.40 [-5.70, -1.10]
Sherwood [28]	59	11.10(6.00)	69	14.50(6.00)	12.69	-3.40 [-5.49, -1.31]
EL-Gharbawy [27]	82	5.60(6.00)	63	10.30(6.00)	14.22	-4.70 [-6.67, -2.73]
Subtotal (95% CI)	757		826		67.07	-3.46 [-4.37, -2.55]
Test for heterogeneity: Chi² = 8.46, df = 13 (P = 0.81), I² = 0%						
Test for overall effect: Z = 7.47 (P < 0.00001)						
02 The UK Non-invasive studies						
Guzzetti [25]	26	5.40(17.00)	26	11.20(23.00)	0.46	-5.80 [-16.79, 5.19]
Chaturvedi [16]Hyper	64	14.00(23.00)	33	17.00(20.00)	0.70	-3.00 [-11.85, 5.85]
Chaturvedi [16] Norm	103	12.00(21.00)	119	17.00(18.00)	2.05	-5.00 [-10.19, 0.19]
Chaturvedi [16] Untr	167	13.00(20.00)	152	17.00(19.00)	3.01	-4.00 [-8.28, 0.28]
Mayet [22]	46	5.50(7.00)	46	10.70(8.00)	5.85	-5.20 [-8.27, -2.13]
Subtotal (95% CI)	406		376		12.07	-4.76 [-6.90, -2.62]
Test for heterogeneity: Chi² = 0.39, df = 4 (P = 0.98), I² = 0%						
Test for overall effect: Z = 4.36 (P < 0.0001)						
03 The UK Intra-arterial studies						
Rowland [12]	16	16.00(17.00)	16	14.00(17.00)	0.40	2.00 [-9.78, 13.78]
Acharya [18] Women	25	17.50(11.00)	218	19.50(10.00)	2.71	-2.00 [-6.51, 2.51]
Acharya [18] Men	31	15.90(11.00)	344	16.30(11.00)	3.38	-0.40 [-4.44, 3.64]
Khattar [26]	54	12.90(7.00)	528	13.70(7.00)	14.37	-0.80 [-2.76, 1.16]
Subtotal (95% CI)	126		1106		20.85	-0.84 [-2.46, 0.79]
Test for heterogeneity: Chi² = 0.52, df = 3 (P = 0.91), I² = 0%						
Test for overall effect: Z = 1.01 (P = 0.31)						
Total (95% CI)	1289		2308		100.00	-3.07 [-3.81, -2.33]
Test for heterogeneity: Chi² = 19.72, df = 22 (P = 0.60), I² = 0%						
Test for overall effect: Z = 8.10 (P < 0.00001)						



b) Diastolic

Review: Nocturnal Blood Pressure Fall
Comparison: 01 African origin versus white in Systolic Nocturnal Fall
Outcome: 02 Diastolic Nocturnal Fall

Study or sub-category	African Origin N	African Origin Mean (SD)	White N	White Mean (SD)	Weight %	WMD (random) 95% CI
01 American studies						
Fumo [15]	22	13.10(17.00)	22	18.70(14.00)	1.14	-5.60 [-14.80, 3.60]
Hebert [19] Women	42	11.20(21.00)	32	14.10(19.00)	1.16	-2.90 [-12.05, 6.25]
Chase [21] Males	20	15.60(15.00)	22	14.90(13.00)	1.33	0.70 [-7.83, 9.23]
Hebert [19] Men	20	10.90(14.00)	40	15.60(16.00)	1.56	-4.70 [-12.59, 3.19]
Chase [21] Female	16	17.80(13.00)	28	20.30(12.00)	1.61	-2.50 [-10.27, 5.27]
James [13]	27	16.70(15.00)	83	21.00(12.00)	2.50	-4.30 [-10.52, 1.92]
Ituarte [24]	59	18.20(13.00)	60	20.90(14.00)	4.11	-2.70 [-7.55, 2.15]
Murphy [14]	44	10.60(12.00)	37	16.90(10.00)	4.22	-6.30 [-11.09, -1.51]
Gretler [17] Women	153	13.30(18.00)	106	17.60(19.00)	4.56	-4.30 [-8.91, 0.31]
Shapiro [20]]	57	16.50(14.00)	85	19.10(12.00)	4.91	-2.60 [-7.04, 1.84]
Gretler [17] Men	122	13.70(19.00)	140	16.50(16.00)	5.27	-2.80 [-7.09, 1.49]
EL-Gharbawy [27]	82	7.00(11.00)	63	10.70(10.00)	8.23	-3.70 [-7.13, -0.27]
Olutade [23]	34	9.40(7.00)	39	13.70(5.00)	12.11	-4.30 [-7.13, -1.47]
Sherwood [28]	59	15.10(8.00)	69	17.10(7.00)	14.04	-2.00 [-4.63, 0.63]
Subtotal (95% CI)	757		826		66.75	-3.39 [-4.60, -2.19]
Test for heterogeneity: Chi² = 4.70, df = 13 (P = 0.98), I² = 0%						
Test for overall effect: Z = 5.52 (P < 0.00001)						
02 The UK Non-invasive studies						
Guzzetti [25]	26	8.20(15.00)	26	16.10(16.00)	1.36	-7.90 [-16.33, 0.53]
Mayet [22]	46	8.40(9.00)	46	13.70(9.00)	7.16	-5.30 [-8.98, -1.62]
Subtotal (95% CI)	72		72		8.52	-5.72 [-9.09, -2.34]
Test for heterogeneity: Chi² = 0.31, df = 1 (P = 0.58), I² = 0%						
Test for overall effect: Z = 3.32 (P = 0.0009)						
03 The UK Intra-arterial studies						
Rowland [12]	16	16.00(18.00)	16	14.00(17.00)	0.66	2.00 [-10.13, 14.13]
Acharya [18] Men	31	17.50(13.00)	344	19.60(13.00)	4.24	-2.10 [-6.88, 2.68]
Acharya [18] Women	25	20.80(11.00)	218	24.20(12.00)	4.58	-3.40 [-8.00, 1.20]
Khattar [26]	54	16.80(9.00)	528	16.80(9.00)	15.25	0.00 [-2.52, 2.52]
Subtotal (95% CI)	126		1106		24.73	-0.94 [-2.92, 1.04]
Test for heterogeneity: Chi² = 2.09, df = 3 (P = 0.55), I² = 0%						
Test for overall effect: Z = 0.93 (P = 0.35)						
Total (95% CI)	955		2004		100.00	-2.98 [-3.97, -2.00]
Test for heterogeneity: Chi² = 14.16, df = 19 (P = 0.77), I² = 0%						
Test for overall effect: Z = 5.94 (P < 0.00001)						

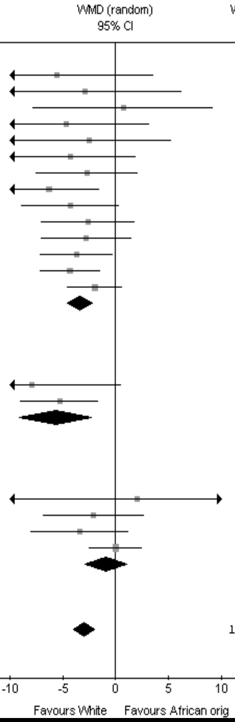
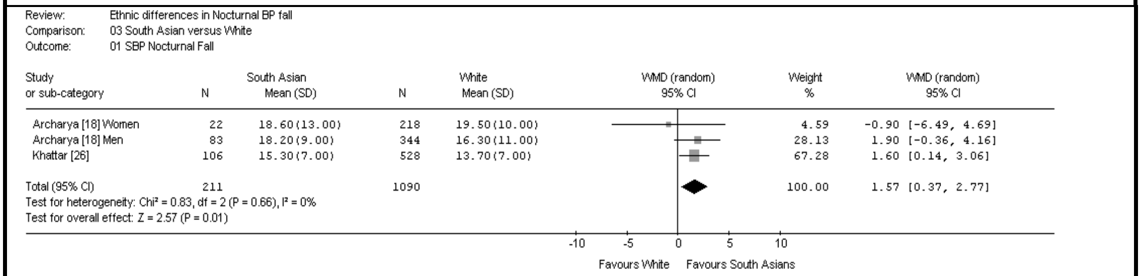
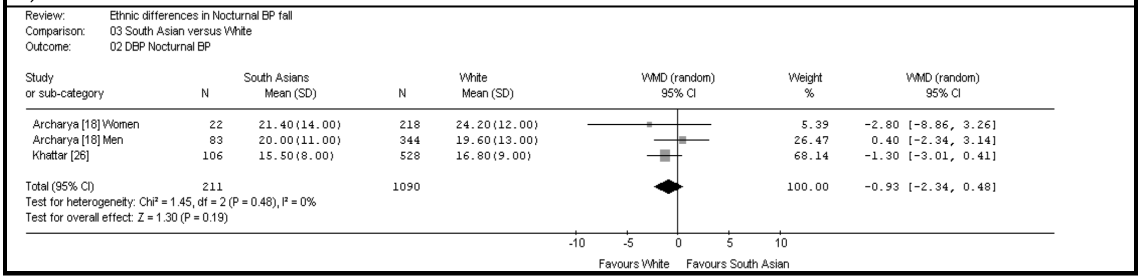


Figure 2 WMD in SBP and DBP percentage nocturnal fall between South Asian and White people in the UK

a) Systolic



b) Diastolic



The findings of the studies are based on the first ABP monitoring readings. Lack of assessment of the reproducibility of the nocturnal BP fall in these studies is also likely to affect the study findings. Differences in the BMI and sex composition of the samples further complicate interpretations. Despite these limitations, the review findings show a consistent lower nocturnal fall in Blacks in most studies.

Discussion of the key findings

People with a diminished or a 'non-dipping' nocturnal BP have a higher risk of all target organ damage and cardiovascular morbid events than those with a dipping nocturnal profile.[33] The finding of a smaller percentage nocturnal BP decline and a higher prevalence of non-dipping (< 10% fall) in Blacks may explain, at least in part, the comparatively high cardiovascular morbidity and mortality among these groups.[34,35] Black populations were more likely to have a smaller nocturnal decline in BP compared with their White counterparts, even with less or similar daytime BP. In one UK study,[22] for example, mean daytime BP was similar but the mean percentage nocturnal BP fall was lower in Blacks compared with Whites.

The 'non-dipping' phenomenon was found not only in African-American hypertensive patients, but also in normotensive subjects in the community settings.[13,15,16,20,21,24]
As the intra-arterial technique is the gold standard for ABP monitoring, it is expected that the nocturnal BP fall derived from a non-invasive technique would follow similar patterns to the intra-arterial technique. However, in Blacks the patterns of nocturnal BP falls derived from intra-

arterial methods differ from non-invasive methods. For example, in UK studies[12,18,26] where the intra-arterial technique was used, the overall BP nocturnal falls were similar and the percentage nocturnal falls was above 10% in all ethnic groups. However, in other UK studies[16,22,25] where non-invasive methods were used, nocturnal BP falls were significantly lower and percentage nocturnal falls was below 10%[22,25] in Blacks compared with Whites. The similar intra-arterial nocturnal BP fall but higher non-invasive nocturnal BP fall requires further study.

The review findings seem to be consistent with the notion that non-dippers are at increased risk of left ventricular hypertrophy.[6] In Mayet et al.'s [22] and Guzzetti et al.'s[25] studies, the percentage nocturnal SBP and DBP falls in Blacks were lower than 10%; the left ventricular mass index was correspondingly significantly greater in Blacks compared with Whites. In Fumo et al.'s[15] study the mean percentage nocturnal SBP fall in Blacks was less than 10%, and the left ventricular mass index was correspondingly higher compared with Whites who had a greater percentage fall (> 10%). In Chaturvedi et al.'s[16] study the percentage nocturnal SBP fall was above 10% in both ethnic groups. The left ventricular mass index was similar in the two ethnic groups although the percentage nocturnal fall was lower in Afro-Caribbeans compared with Europeans. These findings seem to suggest that nocturnal BP falls below 10% are an important determinant of left ventricular hypertrophy in Blacks.

The findings of higher night-time BP levels in Blacks in both the UK and USA studies are consistent with the higher BP levels in older Black people in the UK[2] and the comparatively high BP levels in African Americans in the USA.[4] South Asians of Bangladeshi and Pakistani origins have comparatively high stroke mortality rates that are not explained by their slightly lower BP, and, as shown here, no lack of nocturnal falls.

In conclusion, Blacks have a lower mean nocturnal BP fall and a higher prevalence of 'non-dipping' compared with Whites. South Asians had a higher mean nocturnal SBP fall but a similar DBP nocturnal fall compared with Whites. More studies are needed in South Asians and the heterogeneity within these groups should be recognized.

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Prevalence, Awareness, Treatment, and Control of Hypertension among African Surinamese, South Asian Surinamese and White Dutch in Amsterdam, the Netherlands – The SUNSET study

Charles Agyemang[ab]

Navin Bindraban[ac]

Gideon Mairuhu[c]

Gert van Montfrans[c]

Richard Koopmans[cd]

Karien Stronks[a]

a. **Dept. of Social Medicine, Academic Medical Centre, University of Amsterdam, Amsterdam, The Netherlands**
b. **Institute of Health Policy and Management, Erasmus Medical Centre, Rotterdam, The Netherlands**
c. **Department of Internal Medicine, Academic Medical Centre, Amsterdam, The Netherlands**
d. **Dept. of Pharmacology & Pharmacotherapy, Academic Medical Centre, Amsterdam, The Netherlands**

Published in *Journal of Hypertension* 2005; **23**:1971-77

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Abstract

Objective: To assess ethnic differences in prevalence, levels of awareness, treatment and control of hypertension among Dutch ethnic groups and to determine whether these differences are consistent with the UK findings.

Design: Cross-sectional survey

Setting: South-east Amsterdam, the Netherlands

Participants: A random sample of 1383 non-institutional adults age 35-60 years. Of these, 36.7% were White, 42% were Afro-Surinamese and 21.3% were South Asian people.

Main outcome measures: Prevalence of hypertension, rates of awareness, treatment, and control of hypertension

Results: The Afro-Surinamese and South Asian Surinamse had a higher prevalence of hypertension compared with White people. After adjustments for age, the odds ratios (95% CI) for being hypertensive were 2.2 (1.4 to 3.4; p<0.0001) and 3.8 (2.6 and 5.7; p<0.0001) for Black men and women, respectively and 1.7 (1.0 to 2.6; p = 0.039) and 2.8 (1.8 to 4.5; p<0.0001) for South Asian men and women compared with White people. There were no differences in awareness and pharmacological treatment of hypertension between the groups. However, Afro-Surinamese hypertensive men 0.3 (0.1 to 0.7; p <0.01) and women 0.5 (0.3 to 0.9; p<0.05) were less likely to have their blood pressure adequately controlled compared with White people.

Conclusion: The higher prevalence of hypertension found among Black and South Asian people in the Netherlands are consistent with the UK studies. The lower control rates and the similar levels of awareness and treatment of hypertension in Black Surinamese however, contrast with the higher rates reported in African Caribbeans in the UK. The rates for the South Asians in the Netherlands were, however, relatively favourable than for comparable South Asian groups in the UK. These findings underscore the urgent need to develop strategies aiming at improving the prevention and control of hypertension especially among Afro-Surinamese people in the Netherlands.

Key Words: Prevalence; Awareness; Treatment; Control; Ethnicity, the Netherlands

Introduction

There are striking ethnic differences in cardiovascular diseases in the western hemisphere. Migrants of South Asian descent (Indians, Pakistanis, Bangladeshi) worldwide have elevated risks of coronary heart disease (CHD).[1] On the other hand people of African descent have a comparatively high risk of stroke and end stage renal failure whereas CHD is less common.[1-3] Hypertension is a major risk factor for cardiovascular morbidity and mortality. The risk of cardiovascular disease associated with hypertension is consistent and independent of other risk factors.[4,5] The available data, mostly from the UK[6,7] and USA,[8] suggest that the prevalence of hypertension is higher in some ethnic groups, particularly in African descent populations.[6,8] On the whole, however, the published literature on ethnic differences in hypertension from the UK is less consistent than in the US, where essentially every study has reported higher rates among African Americans.[6] There is also stark heterogeneity in the South Asian groups, with Indians having a higher prevalence of hypertension as compared with their Pakistani and Bangladeshi counterparts in the UK. [7] The UK data show similarities in awareness and treatment of hypertension between South Asian and White people but lower control rates in South Asian men compared with White men.[9,10] Afro-Caribbeans however, had higher rates of awareness and treatment of hypertension compared with White people but the control rates remain inconclusive between the two ethnic groups.[9,10] The current report in the United State showed similar rates of awareness and treatment of hypertension but lower control rate in African Americans compared with White people. [8]

In Europe, apart from the UK, data on hypertension in ethnic minority groups are very limited. The Netherlands belongs to those European countries with an increasing number of migrants. Minority ethnic groups of non-European origin now form approximately 10% of the total population of the Netherlands. Migrants from Surinam, mostly Hindustanis (originating from the Indian subcontinent) and Creole (African descent) form one of the biggest ethnic groups alongside Turkish, Moroccans and Antilleans. Surinam was a former Dutch colony. In 1975 during the process of decolonisation, almost half of the entire Surinam population (both Creoles and Hindustanis) migrated to the Netherlands. These two groups are often combined as one homogeneous group in health surveys. As a result, the cardiovascular risk profiles within these two different ethnic groups are largely blurred. Although Creole Surinamese share a common ancestry with the African descent populations in the West while Hindustani Surinamese share a common ancestry with the South Asian populations, these groups differ considerably in terms of culture, language, migration history, geographical locations, diet, and socio-economic positions, [11] many of which are important determinants of high BP.[12]

There are indications in the Netherlands that prevalence of hypertension is higher in Surinamese migrants than their White Dutch counterparts.[13] However, it is unclear whether these high prevalence rates are found in both Creoles and Hindustanis. Comparing both ethnic groups, which have part of their migration history in common, might give more insight into possible ethnic differences in hypertension. In addition, the Netherlands health care system also differs from both the UK and the USA. A recent report by Manna and colleagues showed that the Dutch clinical practice guideline gives the least attention to ethnic differences in hypertension compared with the USA, Canada, and the UK.[14] Moreover, mortality from stroke, which is generally considered as an indicator of quality of BP control,[15] has recently been shown to increase among the Surinamese population in the Netherlands.[16] So far, it is unknown whether awareness, treatment and control of hypertension differ between the groups in the Netherlands.

The main objective of this paper was to assess ethnic differences in prevalence, levels of awareness, treatment and control of hypertension among Dutch ethnic groups and to determine whether these observed differences are consistent with the UK findings. It is important that cardiovascular risk profiles for each of these groups are established so that appropriate intervention strategies can be developed to prevent cardiovascular diseases.

Data and methods

Study population

Data were obtained from the SUNSET study (acronym for: Surinamese in the Netherlands: Study on Ethnicity and Health). This was a cross-sectional study that aimed to assess the cardiovascular risk profile of three ethnic groups in the Netherlands: Creole, Hindustani and White Dutch people. It is based on a sample of 35-60 year old, non-institutionalized people in South-east Amsterdam, the Netherlands. A random sample of 2000 Surinamese and approximately 1000 White Dutch were drawn from the Amsterdam population register. Between 2001 and 2003, people in these samples were approached for an oral interview. The interviewers were matched by ethnicity and sex. The overall response rate was 63% among the Surinamese and 63.5% among White Dutch. Those who responded to the oral interview were invited for medical examination. The subsequent response rate was 84% among the Surinamese and 98% among the Dutch. All participants signed a consent form. The analyses that are presented here are based on the population that participated in the interview as well as the medical examination. The Medical Ethical Committee of the Amsterdam Academic Medical Center approved the study protocols.

Measurements

People were classified as Surinamese if they were born in Surinam, or had both parents born in Surinam. Approximately 80% of the Surinamese immigrants in the Netherlands are either Creole or Hindustani. Both groups were classified according to the self-reported ethnic origin of the mother of the respondent. In this paper, the Creole and Hindustani are named as Afro-Surinamese and South Asian Surinamese respectively. People were classified as White Dutch if they were born in the Netherlands and had both parents born in the Netherlands. They are named here as White. Height was measured without shoes with a measuring tape to the nearest 0.1 cm. Weight was measured in light clothing to the nearest 0.2 kg. Body mass index (BMI) was calculated as weight (kg) divided by height (m^2) and obesity was defined as BMI ≥30 kg/m^2. Blood pressure and resting heart rate were measured in the morning with a validated oscillometric automated digital BP device (OMRON M-4 device) by trained staff in Amsterdam Academic Medical Centre. Using appropriate cuff sizes, two readings were taken on the right arm in a seated position after the subject had emptied their bladder and had seated for at least five minutes. The mean of the two readings was used in the analyses.

Hypertension was defined as a SBP ≥ 140 mm Hg, or DBP ≥ 90 mm Hg, or being on anti-hypertensive therapy. Awareness of hypertension was defined as self-reporting of any prior diagnosis of hypertension by a health care professional. Treatment of hypertension was defined as the proportion of hypertensives that were receiving prescribed anti-hypertensive medication for management of high BP at the time of the interview. Adequate treatment was defined as the proportion on anti-hypertensive therapy with SBP < 140 mm Hg and DBP < 90 mm Hg.

Data analysis

The *t*-tests were used to assess ethnic differences in continuous variables while chi-square tests were used for categorical variables. Age adjusted mean differences in systolic and diastolic BP levels between the ethnic groups were assessed by multivariate linear regression. Multiple logistic regression analyses were performed to assess ethnic differences in prevalence, awareness, treatment, and control of hypertension adjusting for age. All statistical tests were two-tailed and *p*-values ≤ 0.05 were considered statistically significant. All statistical analyses were performed using SPSS 11.5 for windows (SPSS Inc. Chicago, USA).

Results

Characteristics of the study population

Table 1 shows the characteristics of the study population by ethnic group. Among 1383 subjects included in the analysis, 575 (41.6%) were men and 808 (58.4%) were women. Of these, 505 (36.7%) were White, 581 (42%) were Afro-Surinamese and 294 (21.3%) were South Asian. Afro-Surinamese and South Asian men were significantly younger, shorter and lighter compared with

White men. Afro-Surinamese and South Asian women were significantly younger, shorter, had higher BMI's and were more obese compared with White women. The resting heart rate was higher in Afro-Surinamese and South Asian men and women compared with their White counterparts. The age adjusted mean systolic and diastolic BP were significantly higher in Afro-Surinamese men and women compared with their White counterparts. South Asian men had a similar age adjusted mean systolic BP but a significantly higher diastolic BP compared with White men. The age adjusted mean systolic and diastolic BP were significantly higher in South Asian women compared with White women.

Prevalence, Awareness, Treatment and Control of Hypertension

Figure 1a and 1b show the prevalence of hypertension among male and female participants respectively, stratified by age. Among 35-39 and 40-44 year-old men, the prevalence of hypertension did not differ significantly among the three ethnic groups. However, South Asian 45-49 year-olds and Afro-Surinamese 50+ year-olds had a significantly higher prevalence of hypertension compared with their White counterparts. Afro-Surinamese women in all age groups had significantly higher prevalence of hypertension compared with their White counterparts. South Asian women in age groups 40-44 and 45-49 also had a significantly higher prevalence of hypertension than their White counterparts. After age had been controlled for, the odds of being hypertensive were still over two-fold and nearly four-fold greater in Afro-Surinamese men and women than in their Dutch counterparts (table 2). The age adjusted odd ratios for South Asian men and women were 1.7 and 2.8 respectively as compared with their White counterparts. There were no significant differences in awareness of hypertension between the ethnic groups in both men and women. However, Afro-Surinamese hypertensive men and women were less likely to have their BP adequately controlled; the differences remaining statistically significant after age had been accounted for (table 2). The proportion of hypertensives that were receiving anti-hypertensive medication did not differ significantly between the ethnic groups but the control rates among those on medication was significantly lower in Afro-Surinamese men compared with White men. The age adjusted controlled rates were also lower in South Asian women although the differences were not statistically significant. The lower control rates are reflected in comparatively high mean BP values among Afro-Surinamese untreated and treated hypertensives. On the other hand, the mean values for undetected hypertensives were similar across all ethnic groups in both men and women (Table 3).

Table 1 Characteristics of the population, anthropometrics and blood pressure levels by sex and ethnic group

	Men			Women		
	White (n = 253)	**Afro-Surinamese (n = 187)**	**South Asian (n = 135)**	**White (n = 255)**	**Afro-Surinamese (n = 394)**	**South Asian (n = 159)**
Age (y)	48.1 (47.3, 48.9)	44.1 (43.2, 44.9)***	44.3 (43.2, 45.4)***	47.4 (46.6, 48.2)	43.4 (42.9, 44.0)***	45.0 (44.0, 46.0)***
Height	180.3 (179.0, 181.6)	174.6 (173.4, 175.5)***	169.7 (168.7, 170.6)***	167.2 (165.7, 168.8)	162.9 (162.3, 163.5)***	157.0 (156.0, 158.0)***
Weight	84.1 (82.2, 85.9)	80.4 (78.2, 82.5)**	75.9 (73.3, 78.6)***	73.4 (69.1, 77.7)	78.1 (76.5, 79.7)*	67.8 (65.7, 69.9)*
BMI	26.2 (25.7, 26.8)	26.4 (25.7, 27.0)	26.4 (25.5, 27.2)	26.1 (25.5, 26.8)	29.4 (28.8, 29.9)***	27.5 (26.7, 28.3)*
Obesity (BMI≥30 kg/m^2) %	14.2	18.7	14.8	16.5	42.2***	24.5*
Pulse Rate	67.2 (65.8, 68.7)	69.9 (68.3, 71.6)*	72.8 (70.9, 74.8)***	70.4 (69.1, 71.7)	74.4 (73.4, 75.5)***	74.5 (72.9, 76.2)***
Systolic BP§	126.9 (124.8, 129.0)	134.8 (132.4, 137.2)***	128.4 (125.7, 131.2)	115.5 (113.1, 117.8)	127.9 (126.0, 129.8)***	126.9 (124.0, 129.9)***
Diastolic BP§	81.0 (79.8, 82.4)	87.2 (85.7, 88.7)***	85.5 (83.8, 87.3)***	75.0 (73.6, 76.3)	83.5 (82.4, 84.6)***	81.7 (80.0, 83.3)***
Hypertension %	41.3	47.1	41.5	25.9	46.3***	42.8***
Awareness %	54.8	50.0	53.6	72.7	74.7	79.4
Treatment %	33.3	23.9	28.6	30.8	29.8	44.1
Control (among hypertension)%	24.0	10.2**	23.2	45.5	37.4	41.2
Control (among treated) %	42.1	14.3*	37.5	50.0	48.1	40.0

§Age adjusted. BMI = Body mass index; BP = Blood pressure; *P<0.05, **P<0.01, ***P<0.0001 comparing White group

Table 2 Age adjusted odd ratios and (95% CI) for hypertension, awareness, treatment and control by sex and ethnic group

	Men			Women		
	White (n = 253)	**Afro-Surinamese (n = 187)**	**South Asian (n = 135)**	**White (n = 255)**	**Afro-Surinamese (n = 394)**	**South Asian (n = 159)**
Hypertension	1	2.2 (1.4, 3.4)***	1.7 (1.0, 2.6)*	1	3.8 (2.6, 5.7)***	2.8 (1.8, 4.5)***
Awareness	1	1.2 (0.7, 2.1)	1.0 (0.5, 2.0)	1	1.1 (0.5, 2.1)	0.8 (0.3, 1.7)
Treatment	1	0.7 (0.4, 1.6)	0.9 (0.4, 2.0)	1	1.2 (0.5, 2.6)	2.0 (0.8, 4.8)
Control (among hypertensives)	1	0.3 (0.1, 0.7)**	0.8 (0.4, 1.8)	1	0.5 (0.3, 0.9)*	0.6 (0.3, 1.3)
Control (among treated hypertensives)	1	0.2 (0.1, 0.9)*	0.8 (0.2, 3.0)	1	0.8 (0.2, 3.1)	0.6 (0.2, 2.4)

CI = Confident interval; *P<0.05, **P<0.01; ***P<0.0001 comparing White group

Table 3 Age adjusted mean BP levels and (95% CI) in normotensive, undetected hypertensives, untreated hypertensive and treated hypertensive by sex and ethnic group

Ethnic group	Normotensive		Undetected hypertensive		Untreated hypertensive		Treated hypertensive	
	Systolic	**Diastolic**	**Systolic**	**Diastolic**	**Systolic**	**Diastolic**	**Systolic**	**Diastolic**
Men								
White	119.2 (117.4, 119.5)	76.8 (75.4, 77.9)	146.6 (143.0, 150.2)	94.5 (92.6, 96.5)	137.6 (132.0, 142.2)	86.9 (84.0, 89.8)	138.4 (130.6, 146.2)	86.3 (81.9, 90.8)
Afro-Surinamese	121.6 (119.5, 123.7)	78.5 (77.0, 80.0)	146.2 (142.7, 149.8)	95.2 (93.3, 97.2)	145.9 (142.2, 149.6)*	94.8 (92.7, 97.0)**	150.7 (143.3, 158.1)	97.2 (93.0, 101.5)**
South Asian	117.1 (114.7, 119.5)	78.4 (76.8, 80.1)	143.6 (138.9, 148.2)	95.9 (93.3, 98.4)	141.2 (136.5, 146.0)	94.3 (91.5, 97.0)**	141.2 (132.7, 149.6)	92.7 (87.8, 97.5)
Women								
White	110.5 (108.8, 112.1)	72.0 (71.0, 73.0)	151.0 (141.5, 157.4)	93.8 (90.0, 97.6)	123.1 (115.1, 131.3)	82.5 (77.7, 86.7)	129.7 (116.2, 143.2)	85.6 (78.3, 92.9)
Afro-Surinamese	116.1 (114.5, 117.7)***	76.5 (75.5, 77.4)**	145.4 (141.7, 149.3)	92.5 (90.1, 94.8)	138.5 (134.8, 142.0)**	89.4 (87.4, 91.4)**	144.5 (138.2, 150.8)	93.6 (90.2, 97.0)
South Asian	117.1 (114.7, 119.4)***	76.7 (75.3, 78.2)**	148.7 (141.7, 155.7)	92.2 (88.0, 96.5)	139.2 (132.7, 145.7)**	88.5 (84.9, 92.1)	141.9 (133.8, 150.1)	88.4 (84.0, 92.8)

CI = Confident interval; *P<0.05, **P<0.01; ***P<0.0001 comparing White group

Discussion

Main Findings

The aim of this analysis was to assess prevalence, awareness, treatment and control of hypertension among ethnic minority groups in the Netherlands. The findings show that hypertension is a serious problem in Dutch minority ethnic groups. Nearly 47% of Afro-Surinamese and 42% of South Asian were hypertensive compared with 33% of the White people. There were no differences in awareness and pharmacological treatment of hypertension between the ethnic groups. Afro-Surinamese hypertensive subjects however, were less likely to have their BP adequately controlled.

Discussion of the main findings

Hypertension

Both South Asian Surinamese men and women had a higher prevalence of hypertension compared with their White counterparts. These findings are consistent with South Asian men and White men differences in the UK but contrast similar hypertension rates reported among South Asian women and White women in the UK.[7] In this study, the age adjusted odds of hypertension was 1.7 times and 2.8 times higher in Surinamese South Asian men and women compared with their White counterparts. The prevalence of hypertension was remarkably high among those aged 45 years and above where more than half of the population was hypertensive. The differences in BP and hypertension patterns between South Asian descent populations in the Netherlands and those in the UK may reflect the substantial heterogeneity within these populations.[12] For example, many South Asian populations in the UK are first generation migrants from the Indian subcontinent whereas those in the Netherlands are migrants from Surinam. Current reports from the India also showed a remarkable increase in hypertension rates among urban dwellers. [17]

The finding of a higher prevalence of hypertension in Afro-Surinamese is consistent with the Black and White differences in the UK[6] and the United States[8] studies. Data from the UK demonstrate higher prevalence of hypertension among African descent people compared with White people.[6] In South London, UK, the prevalence of hypertension was 51% in men and 54% in women of African descent compared with 33% and 24% in White men and women (aged 40-59). [10] Similar prevalence rates had also been reported among 40 years and above African descent people in the Health Survey for England.[9] Equally, the recent data from the United States also found a higher prevalence of hypertension among African American men (43%) and women (45%) compared with their White counterparts (29.7% in men and 23.9% in women) aged 35-64 years.[18] Our data presented here demonstrate over two-fold and nearly four-fold greater odds of hypertension in Afro-Surinamese men and women compared with their White counterparts, independent of age. The reasons for the higher prevalence of hypertension among African descent populations living in Western countries are still uncertain.[19]

Awareness, Treatment and Control of Hypertension

Our results show no differences in awareness and pharmacological treatment of hypertension between the ethnic groups. The similar awareness and treatment rates found between South Asian Surinamese and White ethnic groups are consistent with South Asian and White ethnic groups in the UK. [9,10] The similar awareness and treatment rates found between Black Surinamese and White is consistent with African American and White differences in the United States[8] but contrasts with the higher rates reported among African Caribbean in the UK.[6,9,10] Afro-Surinamese hypertensive men and women were less likely to have their BP adequately controlled. The 'rule of halves' predicts that only half of all those with hypertension are detected; half of those detected are treated and half of those treated are adequately controlled.[20] Only 14.3% of Afro-Surinamese men who were receiving anti-hypertensive medication had their BP adequately controlled. This figure is unacceptably low compared with their African American male counterparts in the USA[21] (14.3% versus 48%) and their African Caribbean counterparts in the UK (14.3% versus 57%).[9] The reasons for lower control rates in the Netherlands are unclear. Possible explanations might be poor compliance with anti-hypertensive therapy or lack of aggressiveness in treatment of hypertension among these populations in the Netherlands.[22] The lower attention in ethnic differences in hypertension in the Dutch clinical practice guidelines may also contribute, at least in part, to this lower control rates in the Netherlands.[14] This may reflect lack of awareness among doctors about the higher risk of hypertension among these ethnic groups in the Netherlands. This may have important implications as stroke is related to the quality of BP control. In Du and colleagues' study, the adjusted odds of stroke was ten-fold higher for treated patients with diastolic BP persistently greater than 95 mmHg and over four-fold of systolic BP greater than 160 mmHg compared with those with BP less than 140 and 90 mmHg.[15] The recent mortality data in the Netherlands showed that death from stroke was nearly two-fold greater in Surinamese men compared with Dutch men.[16] This remarkably lower control rate found among Afro-Surinamese men might contribute, at least in part, to this higher stroke mortality reported among this group in the Netherlands. These findings imply that adequate treatment of hypertension especially in Afro-Surinamese men deserve a great attention.

Prevalence of hypertension by age group and ethnic group

Fig 1a

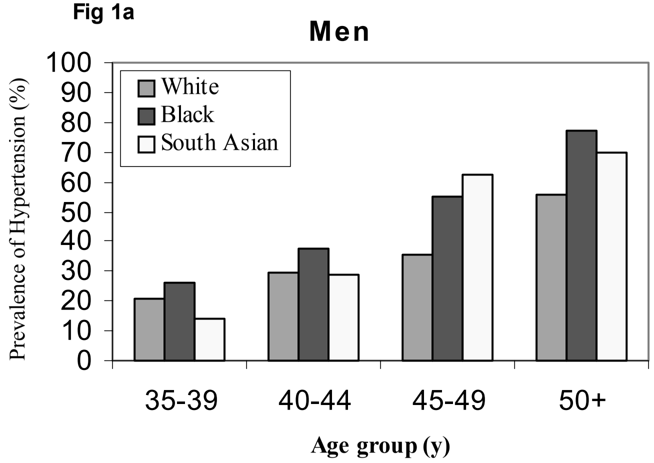
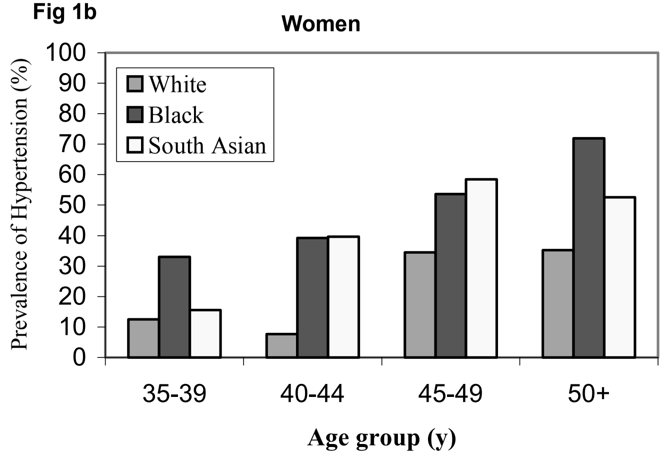


Fig 1b



Limitations

There are limitations to this study. First, like in many surveys our BP levels were based on the average of two measurements at a single visit, which might have overestimated the prevalence rates. A more precise estimate of BP levels would be obtained by multiple measurements obtained during several visits. Other potential sources of bias include the documentation of self-reported hypertensive treatment by the participants. For instance, participants who reported wrongly for not receiving anti-hypertensive therapy and had their BP below 140/90 mmHg were considered normotensives. Similarly, those who reported wrongly for receiving anti-hypertensive treatment and had their BP below 140/90 were considered hypertensive. Nevertheless, these limitations should not limit the comparability of the ethnic groups within the study since these limitations are applied to all the ethnic groups. White-coat also varies between different ethnic groups[23] this may also affect our study findings.

Conclusion

This study shows that prevalence and management of hypertension is an important public health problem in African and South Asian Surinamese populations in the Netherlands. These findings underscore the urgent need to develop strategies aiming at improving the prevention, treatment and control of hypertension among these ethnic groups in the Netherlands. In addition, improving hypertension awareness and control in men, especially in Afro-Surinamese men, will have a positive impact on the higher levels of stroke mortality reported among this group in the Netherlands. The findings of this study should serve as a wake-up call to reinvigorate the efforts of the Surinamese communities and their health professionals to prevent and control the higher prevalence of hypertension among these ethnic groups in the Netherlands.

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Factors associated with hypertension awareness, treatment and control in Ghana, West Africa

Charles Agyemang[1]

Marc A. Bruijnzeels[1]

Ellis Owusu-Dabo[2]

1. **Institute of Health Policy and Management, Erasmus Medical Centre, Rotterdam, The Netherlands**
2. **Kwame Nkrumah University of Ghana, School of Medical Sciences, Kumasi, Ghana**

Published in *Journal of Human Hypertension* 2005 Aug 25

Abstract

Hypertension is rapidly becoming a major public health burden in sub-Saharan/Africa but awareness, treatment and control is lagging behind. We analysed cross-sectional data from Ghana (West-Africa) to examine factors associated with awareness, treatment and control of hypertension. The overall prevalence of hypertension was 29.4%. Of these, 34% were aware of their condition, 28% were receiving treatment, and 6.2% were controlled below SBP/DBP <140/90 mmHg. Multivariate analysis showed that old age was independently associated with higher hypertension awareness: 35-49 year-olds (OR = 2.57, 95% CI: 1.26 - 5.22), ≥ 50 year-olds (OR = 6.14, CI: 2.98 - 12.64) versus 16-34 year-olds. Old age: ≥ 50 year-olds (OR: 6.25, 95% CI: 2.87 - 13.62), trading (OR = 2.46, 95% CI: 1.17 - 5.17), and overweight (OR = 1.85, 95% CI: 1.02, 3.34) were independently associated with pharmacological treatment of hypertension. Trading (OR = 2.51, 95% CI: 1.03 - 7.40) was independently associated with adequate blood pressure (BP) control but old age: ≥ 50 year-olds (OR = 0.11, 95% CI: 0.01 - 0.60) was independently associated with inadequate BP control. The identified factors provide important information for improving BP control among this population. Given the high cost of hypertension medication relative to income, increasing awareness and simple preventive measures such as promotion of physical activity, normalising body weight and reduction of salt intake, present the best hope for reducing the impact of hypertension on morbidity and mortality.

Key Words: Hypertension awareness; treatment; control; Ghana, Africa

Introduction

Hypertension is one of the leading causes of cardiovascular disease and premature mortality in the world and it's role is set to continue.[1] Recent 'Global Burden of Hypertension' data showed that more than a quarter of the world's adult population (nearly one billion) had hypertension in 2000 and this is projected to increase by about 60% (1.56 billion) in 2025; the population burden being greater in developing countries.[2] In traditional African societies, hypertension, once rare,[3] is rapidly becoming a major public health burden.[4-9] The increasing prevalence of hypertension is well reflected in the increasing stroke and cardiovascular disease mortality.[10] At the same time the emerging data also show that hypertension awareness, treatment and control are unacceptably low.[4-9] Establishing factors associated with awareness and management is an essential starting point in preventing increasing burden of morbidity and mortality from hypertension related cardiovascular diseases.[11-13] However, in sub-Saharan/African countries, despite increasing prevalence of hypertension, information on factors associated with awareness, treatment, and control of hypertension is very scarce. The emerging data, mostly from the industrialized nations, indicate that factors such as sex, geographical setting, and body sizes are associated with hypertension awareness, treatment, and control.[11-13] It is unclear however, whether these factors are applicable in very poor resource settings. We analysed data from Ghana to examine factors associated with hypertension awareness, treatment and control among the adult population.

Methods

Data were collected in the regional capital (Kumasi) and four villages in the Ashanti region of Ghana in 2004. In the regional capital, six churches with different denominations, seven schools, and two banks (one bank had 4 branches) were selected randomly from lists of churches, schools and banks. In each village, because of financial constraints, measurements were restricted to every other house. Informed consent was sought from each participant before measurements were taken. The participation rates were high in all the sites ranging from 82% to 99%. Two churches could not give us the total number of the congregate although they expressed that most of the people attended for the measurements. In all the villages, except for two people, none of the people present at the time of measurements refused his/her measurements to be taken. Trained interviewers in local language collected information on demographics, socio-economic status, cigarette smoking status, alcohol consumption, hypertension history, and anti-hypertensive medication use.

Body mass index (BMI) was calculated as weight (kg) divided by height (m^2). Overweight was defined as BMI$\geq$ 25 kg/m^2 and obesity as BMI$\geq$ 30 kg/m^2. BP was measured with an Omron M5-I monitor. Using appropriate cuff sizes, two readings were taken on the right arm in a seated position after at least five minutes rest. The mean of the two readings was used for analysis. The local Ethics Committee approved the study protocol.

Hypertension was defined as a SBP ≥140 mmHg, or DBP ≥ 90 mmHg, or self-reported anti-hypertensive medication use. Awareness was defined as self-reporting of any prior diagnosis of hypertension by a health care professional. Treatment was defined as the proportion of hypertensives that reported receiving prescribed anti-hypertensive medication for management of hypertension at the time of the interview. Control was defined as the proportion on anti-hypertensive therapy with BP<140/90 mmHg.

Data analysis

The proportion of the study subjects with hypertension who were aware of their condition, were receiving treatment, and whose BP was controlled was determined by subjects' characteristics using Chi-square tests. A multivariate analysis using logistic regression was conducted to identify independent factors associated with awareness, treatment, and control of hypertension. These were reported as odds ratios with corresponding 95% confidence intervals. All Statistical analyses were performed using SPSS 11.5 for windows (SPSS Inc. Chicago, USA).

Results

Table 1 shows prevalent rates and multivariate analysis of factors associated with awareness, treatment and control of hypertension. The overall prevalence of hypertension was 29.4%. Among these hypertensives, 34% were aware, 28% were receiving treatment, and only 6.2% were adequately controlled below BP <140/90. The prevalence of hypertension was higher among the older age groups (≥35 year-olds and ≥50 year-olds), those with no education, overweight and obese people, landowners, and alcohol users. In the multivariate analysis, the old age, male sex, inner-city dwelling, overweight and obesity, land ownership, and alcohol consumption were independently associated with hypertension.

Among hypertensives, older age groups, females, those with no formal education, and traders were more likely to be aware of their hypertension diagnosis. In the multivariate analysis, only old age was independently associated with higher awareness of hypertension. There was a tendency of overweight being independently associated with awareness of hypertension (P=0.07).

The older age groups, females, traders, and overweight and obese people were more likely to be receiving medication for their hypertension. In the multivariate analysis, old age (≥50 years), trading, and overweight were independently associated with pharmacological treatment of hypertension.

Among hypertensives, BP control was only more common among current smokers. Among treated hypertensives, the younger age group (16-34 year-olds) and current smokers were more likely to have their BP adequately controlled. However, in the multivariate analysis, being a trader was independently associated with adequate BP control but old aged (≥50 years) was independently associated with inadequate BP control.

Discussion

One of the main central focuses of the primary prevention of cardiovascular disease has been increasing awareness and treatment of patients with hypertension. This has had a positive impact on cardiovascular disease prevention in many countries,[14-19] especially in the USA where the effort had been greatest.[14,15] The increasing awareness and management of hypertension has led to a suggestion that the 'rule of halves' may no longer be applicable in many high-income countries.[20] In some countries especially economically developing nations, however, recent population studies still show that hypertension awareness and management are far from optimal[4-9,18,19] (see table 2). In this study, as in many developing countries, treatment, awareness, and control of hypertension was nowhere near the 'rule of halves'.[20] This is worrying given the escalating prevalence of hypertension in many developing nations.[4-9,18]

The findings of this present study provide important information on factors associated with hypertension awareness, treatment and control in a sub-Saharan/African country setting where information is especially lacking. In the multivariate analysis, we found that old age was independently associated with higher hypertension awareness and treatment that are consistent with other reports.[12,13,21] In contrast,[12,21] the higher awareness and treatment levels among the older age group (≥ 50 years) however, did not correspond to better BP control. In fact, the older adults, on the contrary, were less likely to have their BP adequately controlled compared with younger adults despite their higher awareness and treatment rates. A possible explanation might be that the older people may pay more attention to their health but lack financial means to afford costly anti-hypertensive drugs.[22] The higher control rates among traders may reflect their ability to access medical care, and ability to afford anti-hypertensive medications. A recent report from Ghana shows that 93% of the hypertensive patients interviewed did not comply with their anti-hypertensive treatment.[22] Of these non-compliant patients, 96% cited unaffordable drug prices as the main reason for non-compliance.

Our findings also show that overweight and obese people are more likely to be aware of and treated for hypertension compared with people with normal body weight. These findings are in agreement with recent reports from the USA,[12] Great Britain,[21] and China.[13] It has been suggested that overweight and obesity positively influence BP checking and prescription of medication for intervention; hence higher awareness and treatment.[21] It is debatable whether this suggestion is applicable in developing countries where health care systems are facing many challenges, and more often than not rely on payment at point of entry. Nonetheless, body weight has been shown to be positively associated with socio-economic status, especially with indices of wealth in developing countries.[7] It may well be that in developing countries; overweight or obese people are in a better position to access medical care more frequently and therefore are more aware of and treated for hypertension. This requires further study.

The study has some limitations. First, like in many surveys, our BP levels were based on the average of two measurements at a single visit, which might have overestimated the prevalence rates. Other possible sources of bias include the documentation of self-reported hypertensive treatment by the participants. For example, subjects who reported incorrectly for not receiving anti-hypertensive medication and had BP < 140/90 mmHg were considered normotensives.

In conclusion, the findings of this study have important public health implications. First, old age is associated with awareness of hypertension. Second, old age, trading and overweight are related with pharmacological treatment of hypertension. Third, trading is associated with better BP control but old age is associated with poor BP control despite higher level of awareness and treatment. The identified factors in this study offer a potential starting point for improving awareness and management of hypertension in this sub-Saharan/African population. Given the high cost of hypertension medication relative to income in many developing nations, increasing awareness and simple preventive measures such as promotion of physical activity, normalising body weight and reduction of salt intake, present the best hope for reducing the impact of hypertension on morbidity and mortality. More work is needed to confirm and to identify other potential factors that might be associated with hypertension awareness and management.

Table 1 Prevalence and multivariate logistic regression analysis of factors associated with hypertension, awareness, treatment and control of hypertension among Ghanaian adults

	N	Hypertension (n = 421)		Awareness among hypertensives (n = 143)		Treated among hypertensives (n = 118)		Controlled among Hypertensive (n = 26)		Controlled among treated (n = 26)	
		%	Odd ratios (CI)	%	Odd ratios (CI)	%	Odd ratios (CI)	%	Odd ratios (CI)	%	Odd ratios (CI)
Age group											
16-34 (reference)	771	15.7	1.00	13.2	1.00	10.2	1.00	5.8	1.00	53.8	1.00
35-49	369	31.7***	1.53 (1.09, 2.14)**	34.2***	2.57 (1.26, 5.22)**	25.6**	2.03 (0.92, 4.46)	6.0	0.91 (0.27, 3.10)	23.3**	0.28 (0.06, 1.50)
?50	291	62.9***	6.2 (4.15, 9.13)***	47.5***	6.14 (2.98, 12.64)***	41.1***	6.25 (2.87, 13.62)***	6.6	1.14 (0.33, 3.98)	16.0**	0.11 (0.01, 0.60)**
Sex											
Female (reference)	644	28.0	1.00	40.3	1.00	32.6	1.00	7.2	1.00	22.2	1.00
Men	787	31.0	1.61 (1.19, 2.20)**	27.0**	0.66 (0.58, 1.58)	23.0*	0.75 (0.41, 1.36)	5.0	0.87 (0.30, 2.57)	21.7	0.84 (0.23, 3.11)
Locality											
Rural	578	27.0	1.00	31.4	1.00	26.9	1.00	6.4	1.00	23.8	1.00
Inner city	853	31.1	1.58 (1.14, 2.19)**	35.5	1.58 (0.87, 2.88)	28.7	1.18 (0.63, 2.21)	6.0	0.95 (0.33, 2.77)	21.1	1.02 (0.28, 3.77)
Education level											
No school (reference)	192	52.6	1.00	44.6	1.00	37.6	1.00	7.9	1.00	21.1	1.00
Primary	609	19.4***	0.52 (0.34, 0.82)**	32.2**	1.13 (0.90, 3.59)	23.7**	0.99 (0.48, 2.04)	5.1	0.74 (0.19, 2.88)	21.4	0.48 (0.08, 2.91)
Secondary and above	630	32.1***	0.64 (0.40, 1.04)	29.7**	1.51 (0.57, 2.25)	25.7*	1.24 (0.55, 2.78)	5.9	1.45 (0.38, 5.63)	23.1	1.48 (0.27, 8.31)
Occupation											
Manual (reference)	763	31.8	1.00	34.6	1.00	27.2	1.00	5.8	1.00	21.2	1.00
Non-manual	299	37.1	1.14 (0.78, 1.70)	29.7	0.91 (0.43, 1.92)	23.4	0.85 (0.38, 1.87)	3.6	0.40 (0.09, 1.76)	15.4	0.35 (0.58, 2.10)
Traders	213	27.2	0.87 (0.57, 1.32)	44.4**	1.46 (0.71, 3.00)	44.8*	2.46 (1.17, 5.17)**	13.8	2.51 (1.03, 7.40)*	30.8	1.26 (0.30, 5.32)
Students	156	5.8***	0.26 (0.12, 0.63)**	0.0*	-	0.0	-	0.0	-	0.0	-
Body sizes											
Normal (reference)	934	22.9	1.00	25.7	1.00	20.6	1.00	5.6	1.00	27.3	1.00
Overweight	284	40.8***	1.69 (1.21, 2.37)**	43.1**	1.67 (0.96, 2.92)	35.3*	1.85 (1.02, 3.34)*	6.0	1.14 (0.40, 3.24)	17.1	0.58 (0.16, 2.09)
Obesity	103	52.4***	3.73 (2.27, 6.13)***	48.1**	1.79 (0.86, 3.70)	38.9**	1.90 (0.86, 4.09)	7.4	1.08 (0.27, 4.17)	19.4	0.28 (0.05, 1.66)
Land ownership											
No (reference)	763	24.1	1.00	31.5	1.00	26.1	1.00	5.4	1.00	20.8	1.00
Yes	668	35.5***	1.38 (1.04, 1.84)*	35.9	0.96 (0.58, 1.58)	29.5	0.92 (0.55, 1.56)	6.8	1.08 (0.42, 2.79)	22.9	1.80 (0.57, 5.67)
Smoking status											
No (reference)	1385	29.5	1.00	34.0	1.00	27.9	1.00	5.6	1.00	20.2	1.00
Current smoker	46	26.1	0.30 (0.13, 0.70)**	33.3	0.62 (0.11, 3.45)	33.3	0.80 (0.14, 4.49)	25.0**	2.50 (0.25, 25.17)	75.0**	3.23 (0.10, 88.00)
Alcohol											
No (reference)	1168	26.5	1.00	33.9	1.00	27.7	1.00	6.1	1.00	22.1	1.00
Yes	268	42.2***	1.60 (1.14, 2.26)**	34.2	1.23 (0.69, 2.19)	28.8	1.20 (0.65, 2.20)	6.3	0.80 (0.22, 2.26)	21.9	0.38 (0.09, 1.58)

CI = confidence intervals. *P<0.05, **P<0.01, ***P<0.0001

Table 2 Hypertension awareness, treatment and control among those with hypertension (BP≥140/90 or on medication) in selected population studies in sub-Saharan/Africa and other part s of the world

First author	Country	Hypertension %			Awareness (hypertensives) %			Treated (hypertensives) %			Controlled (hypertensives) %		
		Men	Women	All	Men	Women	All	Men	Women	All	Men	Women	All
	Sub/Saharan/Africa												
Ibrahim et al 1995[9]	Egypt (national)	25.7	26.9	26.3	NG	NG	37.5	NG	NG	23.9	NG	NG	8.0
Edwards et al 2000[4]	Tanzania (urban & rural)	30.0	28.6	NG	NG	NG	20	NG	NG	10.0	NG	NG	1.0
Steyne et al 2001[8]	South Africa (national)	22.9	24.6	23.9	26.0	51.0	NG	21.0	36	NG	10	18	NG
Bovet et al 2002[7]	Tanzania (urban)	27.1	30.2	NG	22.8	37.0	31.0	7.6	13.7	11.2	2.6	4.3	6.5
Amoah 2003[6]	Ghana (urban)	27.6	29.5	28.4	NG	NG	34.0	NG	NG	18.0	NG	NG	4.0
Cappuccio et al 2004[5]	Ghana (semi-urban & rural)	29.9	29.0	28.7	13.9	27.3	22.0	7.8	13.6	11.3	4.4	1.7	2.8
	Other parts of the world												
Hajjar I 2003[15]	USA (national)	27.1	30.1	28.7	66.3	71.2	68.0	54.3	62.0	58.4	32.6	29.6	31.0
Cifkove et al 2004[17]	Czech Republic (national)	42.3	31.1	NG	63.0	74.4	NG	44.3	60.7	NG	16.4	25.4	NG
Gu et al. 2004[19]	China (national)	28.6	25.8	27.2	39.1	50.8	44.7	23.5	33.8	28.2	6.1	10.5	8.1
Psaltopoulou et al, 2004[18]	Greece (national)	45.2	43.8	44.4	46.4	60.2	54.4	37.6	51.4	45.7	12.7	17.1	15.2
Primatesta et al.[16]	England (national)	33.1	30.1	NG	59.7	63.9	61.7	43.1	52.4	47.7	20.6	23.0	21.8

Control BP<140/90; NG = Not given

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Blood pressure in rural, semi-urban and urban children in the Ashanti region of Ghana, West Africa

Charles Agyemang[1]

W.Ken Redekop[2]

Ellis Owusu-Dabo[3]

Marc A. Bruijnzeels[1]

1. **Institute of Health Policy and Management, Erasmus Medical Center, Rotterdam, The Netherlands**
2. **Institute for Medical Technology Assessment, Erasmus Medical Center, Rotterdam, The Netherlands**
3. **Kwame Nkrumah University of Ghana, School of Medical Sciences, Kumasi, Ghana**

To be published in *BMC Public Health* (in press)

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Abstract

Background: High BP, once rare, is rapidly becoming a major public health burden in sub-Saharan/Africa. It is unclear whether this is reflected in children. The main purpose of this study was to assess BP patterns among children in a sub-Saharan Africa setting and to determine whether the increasing prevalence of hypertension reported among adults are reflected in children.

Methods: We conducted a cross-sectional survey among school children aged 8-16 in Ashanti region of Ghana (West-Africa). There were 1277 children in the study (616 boys and 661 females). Of these 214 were from rural, 296 from semi-urban and 767 from urban settings.

Results: BP increased with increasing age. The rural boys had a lower systolic and diastolic BP than semi-urban boys (104.7/62.3 vs. 109.2/66.5; $p<0.001$) and lower systolic BP than urban boys (104.7 vs. 107.6; $P<0.01$). Girls had a higher BP than boys (109.1/66.7 vs. 107.5/63.8; $p<0.01$). With the exception of a lower diastolic BP amongst rural girls, no differences were found between rural girls (107.4/64.4) and semi-urban girls (108.0/66.1) and urban girls (109.8/67.5). In multiple linear regression analysis, excess body weight was independently associated with BP in both boys and girls. Rural boys had a lower high-normal (5.4% vs. 14.7%; $p<0.05$) and elevated systolic BP (9% vs. 21.7%; $p<0.01$) than semi-urban boys. The prevalence of high-normal systolic BP (12.6% vs. 8%; $p<0.01$) and elevated diastolic BP (9.5% vs. 5.5%; $p<0.01$) was higher in girls than in boys. BP levels among Ghanaian children are similar to African and White American children; a different pattern from the 1970's report where BP levels were lower among Ghanaian children at all ages.

Conclusion: The high BP levels found among these African children underscores the urgent needed for public health measures to prevent high BP and its sequelae from becoming another public health burden. This could be achieved by implementing cost-effective measures such as promotion of physical activity and reduction of salt intake through the school curriculum. More work on BP in children in sub-Saharan African and other developing countries are needed since high BP is becoming a major burden in many of these countries.

Key Words: Blood pressure, hypertension, children, Ghana

Introduction

High blood pressure (BP) has been identified as one of the leading causes of cardiovascular disease and premature mortality in the world.[1] In traditional African societies, high BP, once rare,[2] is rapidly becoming a major public health burden.[3-6] The recent data show a prevalence rates as high as 33% in some communities.[3,4] The increasing prevalence of hypertension is well reflected in the increasing stroke and cardiovascular disease morbidity and mortality.[7,8] These grim statistics imply that more studies are needed on the cardiovascular front as advocated by the WHO to determine the main causes in order to design programs to prevent this pandemic especially among the young where data are very scarce.[9]

In children, BP tracking patterns confirm that persistent BP elevation may be related to hypertension in adulthood.[10,11] The emerging evidence also suggests that primary hypertension is detectable and occurs commonly in the young. [12] In addition, the presence of elevated BP in childhood has been linked with left ventricular hypertrophy.[13] As a result, in most western countries assessment and management of BP in childhood is strongly recommended to promote improved cardiovascular health in adulthood.[12] Many epidemiological studies in various countries have been conducted to determine normal standard reference levels for age, sex, and body size. [12,14] However, in sub-Saharan African countries, BP data in children and adolescents are very scanty. It is unclear whether the recent rapid increases in BP and prevalence of hypertension in adults in sub-Saharan Africa are reflected in children. Given the burden of communicable diseases in many sub-Saharan Africa countries, the rising levels of non-communicable diseases do not bode well for the future. It is important to examine BP levels among children from developing countries so that appropriate cost-effective interventions can be introduced early in life to prevent double burden of diseases in adulthood. The main purpose of this study was to assess BP patterns among children in a sub-Saharan Africa setting and to and to determine the association of blood pressure with locality and BMI in this Sub-Saharan African setting.

Ghana is one of the sub-Saharan countries with increasing prevalence of hypertension. Recently, Cappuccio and colleagues reported as high as 33% prevalence rate among semi-urban adults in Ashanti region of Ghana.[4] In the 1970's the BP levels among Ghanaian children were shown to be lower compared with African American and White American children at all comparable ages.[15] The recent report on BP among White and African American children[16] offer an important opportunity for re-assessing BP levels among Ghanaian children and to determine how BP levels may be changing over time. Furthermore, the recent BP report among Italian children also offers an opportunity to widen our comparisons for future reference.[14]

Methods

Study area

Ghana is located on West Africa's Gulf of Guinea, only a few degrees north of the Equator with a total area of 238,540 square kilometres. It borders Côte d'Ivoire to the west, Burkina Faso to the north, Togo to the east and the Gulf of Guinea to the south. According to the 2000 census, the total population was about 18,800,000 with annual growth rate of 2.4 %. The literacy rate is 74.8%. The predominant religion is Christianity (69%), followed by Islam (15.6%), traditional religions (8.5%), and other religions (6.9%). The life expectancy in 2001 was 56.2 years for men and 59.3 years for women. The GNP per capita in 2002 was US $1,900. Data for this study were collected in the Ashanti region, a region found near the centre of the country. It covers an area of 24,390 square kilometres representing 10.2% of the land area of Ghana. The region produces most of the country's cocoa, minerals and timber.

Data were collected in seven primary schools among healthy children between the ages of 8 to 16 years in the cool season (August-September 2004). Four schools in the urban regional capital (Kumasi) were randomly selected from the schools' lists, two schools in semi-urban and one school in rural setting. Rural refers here to a village without electricity and main water supply, where the main occupation is subsistence farming. The sub-urban villages have electricity and main water supply, and the main occupation is subsistence farming. The schools were visited prior to the data collection in order to obtain permission from the relevant school principals as well as from the children. Following the local rules, the village chiefs and elders were also contacted in advance to obtain their permission. Because only physical measurements were made, only verbal informed consent was sought from the children and their guardians before measurements were taken. Data collection took place during normal school hours. In each school, all children age 8-16 years were included except for one big school in the regional capital where every other class was included. None of the children in the schools refused to participate in this study. Height was measured without shoes with a measuring tape to the nearest 0.5 cm. Weight was measured to the nearest 0.1 kg after removal of shoes, jackets, heavier clothing and pocket contents (using an Electronic Korona Profimed scale, Germany). Body mass index (BMI) was calculated as weight (kg) divided by height (m^2). Children were classified as being overweight according to the BMI-for-age cut-off points corresponding to an adult BMI of 25kg/m^2. [17] Blood pressure and pulse were measured in the morning with a validated oscillometric automated digital blood pressure device (Omron M5-I monitor). Using appropriate cuff sizes, two readings with one-minute interval were taken on the right arm with the child in a seated position after at least five minutes rest. The mean of the two readings was used for analysis. The same trained staff made blood pressure measurements in all locations. In each school, prior to blood pressure measurements in children, all the teachers including the head-teacher had their blood pressure measured in front of the children to allay apprehension. The Committee on Human Research Publication and Ethics, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana approved the study protocol.

Data analysis

Age specific mean systolic and diastolic blood pressure levels were determined for rural, semi-urban and urban groups. The association between blood pressure and age was examined using linear regression analysis. Multiple linear regression analysis enabled age-adjusted comparisons of systolic and diastolic blood pressure levels to be made between gender and locality. The prevalence of 'high-normal' and elevated BP was assessed by comparing the subjects' systolic and diastolic BP with age, sex, and height specific 90th and 95th percentile reference values from the National High Blood Pressure Education Program (NHBPEP) [12] using the CDC growth chart reference percentiles for height. [18] BP between the 90 and 95 percentiles was classified as 'high normal' and ≥95 percentile as elevated BP. [12] Multiple linear regression analyses were also performed separately for boys and girls to assess the independent contribution of locality and BMI to systolic and diastolic blood pressure after adjustment for other factors associated with blood pressure in univariate analyses, including age and resting heart rate. All statistical analyses were performed using SPSS for Windows version 11.5 (SPSS Inc. Chicago, USA).

For the second research question we plotted the age-specific systolic and diastolic BP profiles of Ghanaian children against African American, White American, and Italian children BP profiles that were published recently.[14,16]

Results

Table 1 shows the characteristics of the study population, anthropometrics, BP levels and prevalence of high-normal and elevated BP. There were 1277 participants in the study (616 boys and 661 females). Of these 214 were from rural, 296 from semi-urban and 767 from urban settings.

Blood pressure levels, high normal and elevated BP

The systolic and diastolic BP increased with increasing age in both boys and girls (figure 1a and Ib). This trend was also seen in rural, semi-urban and urban settings (Table 2). In a simple regression, systolic and diastolic BP increased by 3.0 mmHg and 1.0 mmHg per year respectively for rural children, and 2.0 mmHg and 0.6 mmHg per year respectively for semi-urban children, and 2.4 mmHg and 1.0 mmHg for urban children. All regression coefficients were statistically significant (P<0.001). The age adjusted mean systolic and diastolic BP levels were significantly lower in boys than in girls. The prevalence of high-normal systolic BP was significantly lower in boys than in girls. Prevalence of elevated BP was also lower in boys than in girls although the difference was only statistically significant for diastolic BP.

Rural boys versus semi-urban boys and urban boys

As table 1 shows, the age adjusted mean systolic and diastolic BP were significantly lower in rural boys compared with semi-urban boys. The prevalence of high-normal and elevated systolic BP were also significantly lower in rural boys compared with semi-urban boys. The prevalence of high-normal and elevated diastolic BP were also lower in rural boys than in semi-urban boys although the differences were not statistically significant.

Compared with urban boys, rural boys had a significantly lower age adjusted mean systolic BP but a similar diastolic BP. No significant differences in prevalence of high-normal and elevated BP were found although the urban boys had a tendency to have a higher prevalence of systolic elevated BP (P=0.06).

Rural girls versus semi-urban girls and urban girls

The age adjusted mean systolic and diastolic BP levels were lower in rural girls compared with urban girls although the difference was significant only for diastolic BP. No significant differences were seen between rural girls and semi-urban girls except for a lower resting heart rate in semi-urban girls. Compared with the NHBPEP reference values, considerable proportions of Ghanaian girls in all localities had a high-normal and elevated BP particularly systolic BP. No significant differences were found between the groups regarding high-normal and elevated BP although urban girls may have had a higher prevalence of high-normal diastolic BP than rural girls (P=0.07).

Table 3 shows that boys living in a rural area had lower systolic and diastolic BP levels than other boys, while BMI was positively associated with systolic and diastolic BP. Among girls, rural locality was independently associated with lower diastolic BP while BMI was positively associated with both systolic and diastolic blood pressure.

Figure 2a-2d show sex and age-specific systolic and diastolic BP comparisons between Ghanaian children and African American, White American, and Italian children. Ghanaian boys appeared to have a similar systolic and diastolic BP compared with White and African American children but lower compared with Italian boys. Ghanaian 12 to 16 year-old girls appeared to have a higher systolic and diastolic BP compared with White and African American girls but similar to that of the Italian girls.

Discussion

Key findings

Blood pressure levels were lower in the rural populations than in the semi-urban and urban population. Locality and BMI were independently associated with blood pressure in both boys and girls. Considerable proportions of Ghanaian children had high-normal and elevated BP levels compared with the NHBPEP reference values. Blood pressure levels among Ghanaian children are similar to White and African American children.

Discussion of Key findings

The increase of BP with increasing age is consistent with previous reports in Ghana.[4,5,15] This was not only seen in semi-urban and urban settings but also in the rural setting. Less than half a century ago, ancestral African populations living traditional lives showed a lower mean BP with little or no increase with age, and low prevalence of hypertension.[2] In this present study however, both systolic and diastolic BP increased with age (3 mmHg and 1.0 mmHg per year of age) in rural children. Also, compared with the NHBPEP reference values, significant proportions of rural boys and girls had high-normal and elevated BP levels. These findings seem to suggest that the protective effect against high BP in rural settings in sub-Saharan Africa is fading at an alarming rate. Possible explanations for these BP trends in rural setting may be due to increasing changes in lifestyles among these societies such as diet with more salt and fats, reduced physical activity, and higher psychosocial stress. Overweight, salt consumption and reduced physical activity are well-established risk factors for high BP.[19,20]

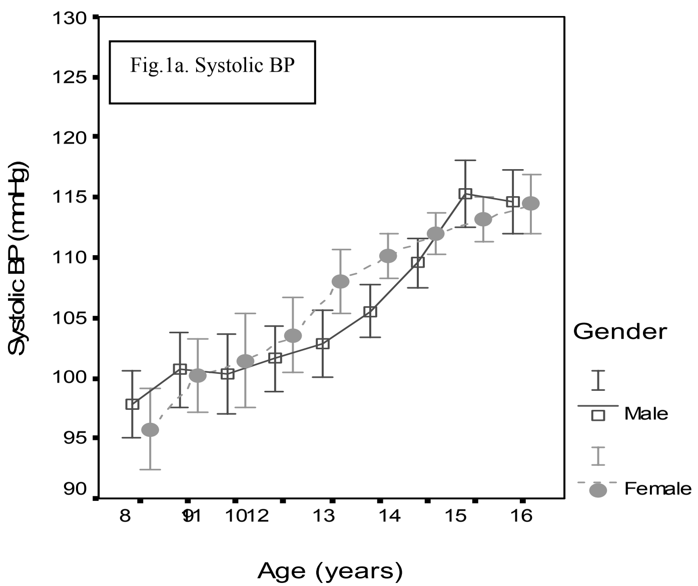
The lower BP level found among rural school children is also consistent with the adult studies in Ghana[4,5] and other reports in sub-Saharan Africa.[21,22] For example, in Cappuccio *et al's* study, BP was generally more favorable for rural dwellers than semi-urban dwellers in Ghana.[4] Boys had more favorable BP profiles than girls. Prevalence of high-normal systolic BP and elevated diastolic BP was lower in boys compared with girls. These gender differences in BP patterns are consistent with earlier findings in the Greater Accra region of Ghana in both children[15] and adult[5] studies but contrast with findings of Cappuccio and colleagues in the Ashanti region of Ghana.[4]

Table 1: Characteristics of the population, anthropometrics and blood pressure levels by gender and locality

	Sex		Boys			Girls		
	Boys (n= 616)	**Girls (n= 661)**	**Rural (n = 111)**	**Semi-urban (n = 143)**	**Urban (n = 362)**	**Rural (n = 103)**	**Semi-urban (n = 153)**	**Urban (n = 405)**
Age (y)	12.9 (2.3)	13.0 (2.1)	12.7 (0.2)	11.8 (0.2)**	13.4 (0.2)***	12.6 (0.2)	12.5 (0.2)	13.2 (0.1)**
Height	147.2 (0.6)	148.8 (1.6)	141.5 (1.2)	137.8 (1.2)*	150.7 (0.7)***	142.2 (1.1)	142.0 (1.0)	149.5 (0.6)***
Weight	38.8 (0.4)	41.2 (0.4)***	34.8 (0.9)	32.1 (0.8)*	42.7 (0.5)***	36.1 (1.0)	36.4 (0.8)	44.3 (0.5)***
BMI	17.7 (0.1)	18.8 (0.1)***	17.1 (0.2)	16.5 (0.2)**	18.4 (0.2)***	17.6 (0.3)	17.7 (0.3)	19.5 (0.2)***
Overweight %	3.1	6.4***	0.0	1.4	4.6*	4.9	1.3	8.6
Pulse Rate	78.7 (0.5)	85.3 (0.5)***	82.5 (1.1)	78.3 (1.2)*	77.7 (0.7)***	88.9 (1.0)	79.5 (1.0)***	86.7 (0.7)
Systolic BP#	107.5 (0.4)	109.1 (0.4)**	104.7 (1.1)	109.2 (1.0)***	107.6 (0.6)**	107.4 (1.0)	108.0 (0.8)	109.8 (0.5)
Diastolic BP#	63.8 (0.4)	66.7 (0.3)***	62.3 (0.7)	66.5 (0.7)***	63.1 (0.4)	64.6 (0.9)	66.1 (0.7)	67.5 (0.5)**
High Normal								
Systolic BP %	8.0	12.6**	5.4	14.7*	6.1	13.6	10.5	13.1
Diastolic BP %	8.0	8.2	7.2	13.3	6.1	3.9	7.8	9.4
Elevated BP								
Systolic BP %	16.1	19.1	9.0	21.7**	16.0	17.5	18.3	19.8
Diastolic BP %	5.8	9.5**	6.3	8.4	4.7	9.7	10.5	9.7

Results are mean (SE); # Age adjusted. BMI = Body mass index; BP = Blood pressure; *P<0.05, **P<0.01, ***P<0.001

Figure 1a and 1b Systolic and diastolic blood pressure by age and gender (results are shown as mean and SE)



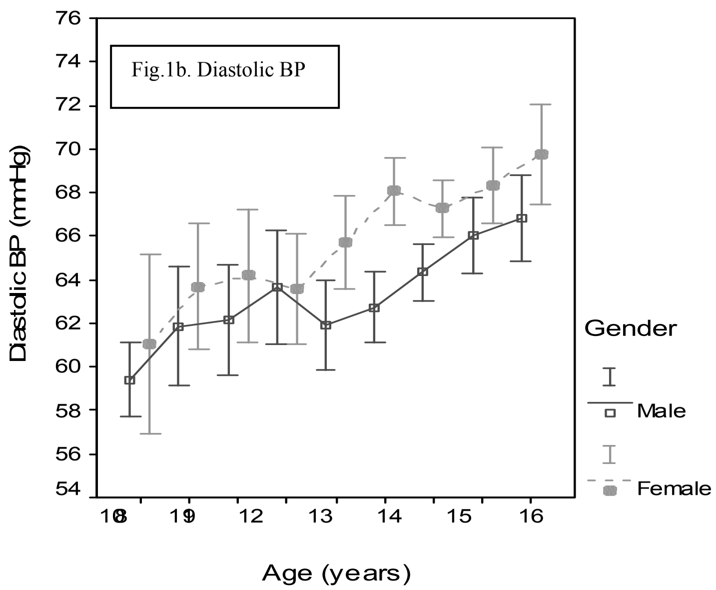


Table 2 Mean (SE) Systolic and diastolic blood pressure (mm Hg) by age group and locality

	Rural (n = 213)			Semi-urban (n = 296)			Urban (658)		
Age (y)	n	Systolic BP	Diastolic BP	n	Systolic BP	Diastolic BP	n	Systolic BP	Diastolic BP
8	18	86.0 (2.4)	51.0 (1.7)	32	96.3 (1.5)	59.8 (1.4)	28	97.9 (1.6)	59.9 (1.4)
9	13	94.1(2.7)	57.8 (1.8)	24	103.5 (1.5)	65.8 (1.5)	25	98.6 (1.4)	59.8 (1.8)
10	20	98.4(2.3)	62.2 (1.7)	27	101.4 (2.1)	64.0 (1.5)	29	97.4 (2.3)	58.4 (2.1)
11	31	100.4 (1.9)	61.5 (1.5)	34	104.3 (1.6)	66.0 (1.6)	26	103.2 (1.9)	66.8 (1.6)
12	29	103.5 (2.6)	64.4 (1.9)	34	108.7 (2.1)	66.4 (1.5)	68	102.6 (1.1)	60.7 (0.9)
13	30	105.6(1.7)	63.5 (1.4)	32	109.4 (1.7)	68.4 (1.2)	140	105.7 (1.0)	61.5 (1.0)
14	33	107.5 (2.0)	62.2 (1.0)	48	111.9 (1.8)	67.6 (1.2)	197	109.6 (1.2)	63.9 (0.6)
15	22	114.5 (2.6)	65.9 (1.7)	37	111.2 (1.8)	65.3 (1.4)	104	115.9 (1.6)	66.4 (1.1)
16	18	115.7 (2.3)	68.4 (1.9)	28	113.4 (1.7)	66.9 (1.5)	41	115.1 (1.4)	66.4 (1.2)
P value		<0.0001	<0.001		<0.0001	<0.0001		<0.0001	<0.0001

P value for linear regression

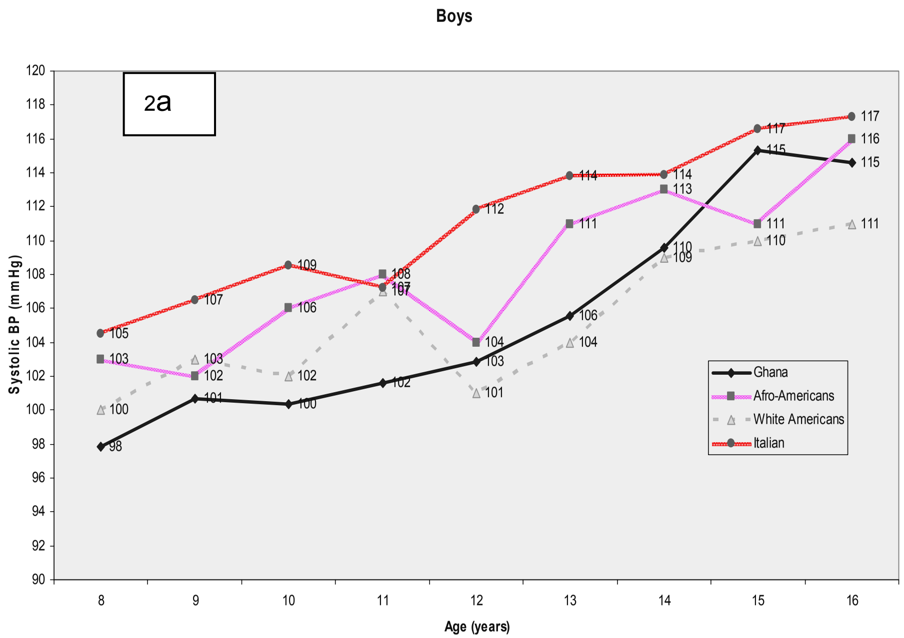
Table 3: Multiple regression analysis of factors associated with systolic and diastolic blood pressure

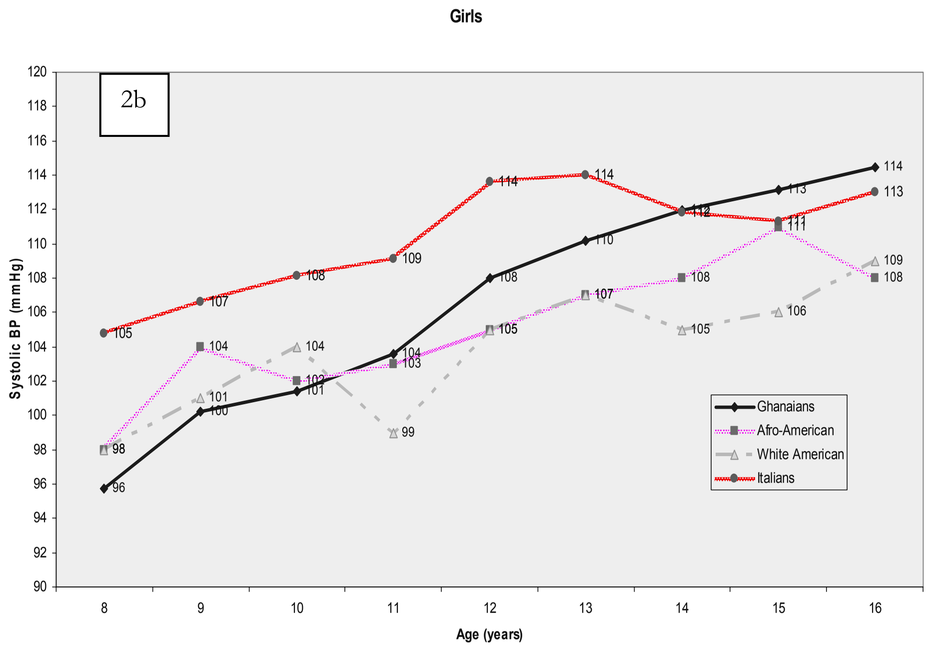
	Systolic blood pressure			Diastolic blood pressure		
Boys	Beta	SE	p-value	Beta	SE	p-value
Rural locality	-3.53	1.16	0.003	-1.71	0.84	0.043
BMI	1.63	0.24	<0.0001	0.60	0.17	<0.0001
Age	1.64	0.24	<0.0001	0.53	0.17	0.002
Heart rate	0.13	0.04	0.001	0.06	0.03	0.016
R^2	0.28			0.08		
Girls						
Rural locality	-0.07	1.09	0.325	-2.06	0.93	0.026
BMI	1.03	0.17	<0.0001	0.69	0.14	<0.0001
Age	1.68	0.22	<0.0001	0.54	0.19	0.005
Heart rate	0.16	0.03	<0.0001	0.13	0.03	<0.0001
R^2	0.25			0.12		

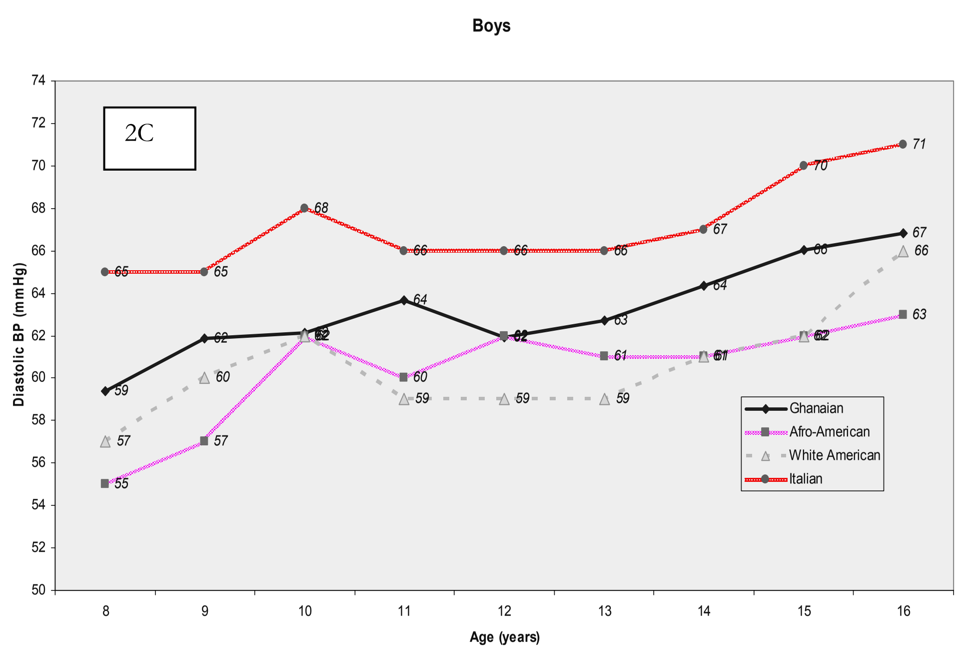
BMI = Body Mass Index

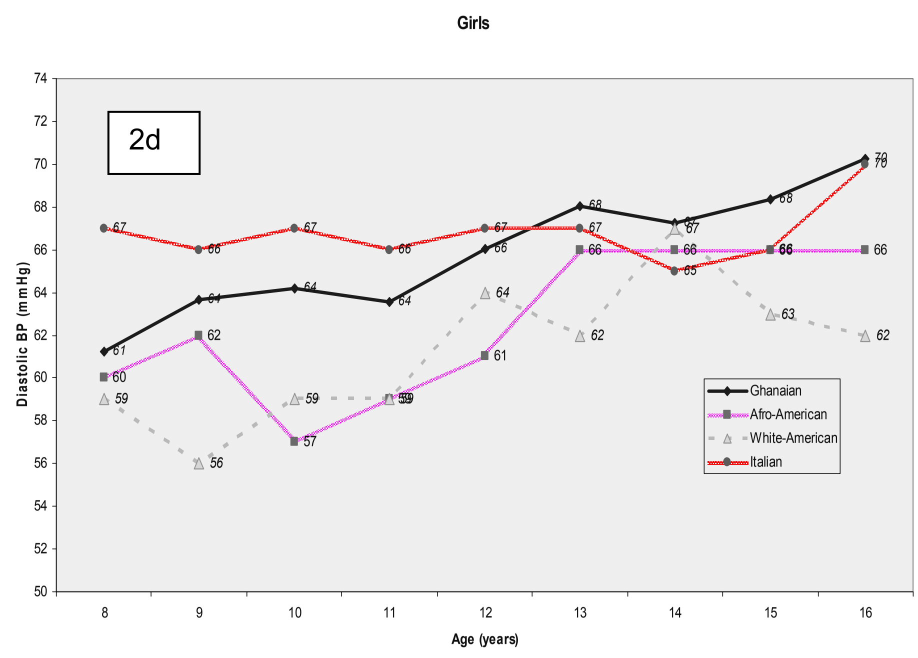
This is surprising given that Cappuccio et al's study was conducted in the same region as ours. Nonetheless, gender differences in BP are generally inconsistent among African origin populations.In our recent report on BP levels in ethnic minority children in the UK,[23] BP levels were generally more favorable for girls than for boys of African descent, while for adults, BP patterns were more favorable for males than for females.[24]

Fig 2a-2d Age specific mean systolic and diastolic BP comparisons between Ghana children and African American, White American, and Italian children






Boys
2C
Diastolic BP (mmHg)
Age (years)
Ghanaian
Afro-American
White American
Italian


Girls
2d
Diastolic BP (mmHg)
Age (years)
Ghanaian
Afro-American
White-American
Italian

The strong and independent association between BMI and BP is worrisome especially among females in urban Ghana. Although the mechanisms by which excess weight may lead to hypertension are poorly understood, Sinaiko and colleagues' prospective study showed that an increase in weight and BMI in childhood are significantly associated with an increase in high BP and other cardiovascular diseases in adulthood.[25] In our study, both urban boys and girls had a higher BMI and were more likely to be overweight compared to their rural counterparts. Rapid urbanization has been associated with a less active lifestyle and an increase in high fat intake. [22] If this trend of overweight is left unchecked while urbanization and westernization continues it may lead to an increase in hypertension and other cardiovascular risks in future generations of Ghanaians. In addition, the multiple regression models explained only 8% to 28% of the variance in systolic and diastolic BP. This implies that more work is needed to determine the other factors that might contribute to an increase in BP among Ghanaian children.

The considerable proportion of Ghanaian children (especially semi-urban boys) with high-normal or elevated BP corresponds with the higher prevalence of hypertension recently reported amongst Ghanaian adults.[4,5] The high prevalence of high normal and elevated BP observed in the semi-urban boys is consistent with the higher prevalence rate reported among semi-urban adults in Ghana.[4] Cappuccio and colleagues[4] found 32.9% of the semi-urban adults to be hypertensive compared with 28.3% in urban setting.[5] The reasons for these differences are difficult to explain but it may well be that the process of modernization has a larger impact on people living in semi-urban settings than relatively well-off people living in urban setting. This requires further study. On the international level, BP levels among Ghanaian children appeared to be similar to African American and White American children of comparable age. These are worrying findings because less than three decades ago both systolic and diastolic BP levels were comparatively low in Ghanaian children compared with African American and White American children at all ages. [15] At the same period, prevalence of hypertension was also low among Ghanaian adult populations (only 4.5% among rural dwellers and 8% to 13% among city dwellers).[6] Recent studies however, show that the prevalence of hypertension among Ghanaian adults has increased considerably in the last 25 years in rural (24.1%), semi-urban (32.9%).[4] In the Bogalusa Heart Study, children with high-normal or elevated BP were more likely to become hypertensives in adulthood. [10] Also in the Muscatine study, children with BP above the 90th percentile had a relative risk of 2.4 for developing hypertension in adulthood.[11] If these high BP levels among Ghanaian children persist, they could lead to considerable increases in BP levels in adulthood over the next generation superseding the comparatively high prevalence of hypertension reported in African Americans. [3] The high BP levels found among Ghanaian children do not bode well for the future especially at a time when urbanization and westernization are proceeding at a faster rate.[9] The stark reality appears even more daunting. In 2003 for example, stroke and cardiovascular disease were the 6th the 7th most common causes of deaths in the Ashanti region of Ghana.[8] High BP is a major contributing factor for stroke and cardiovascular diseases.[7,26]

Limitations

Like many population-based surveys our BP level is based on an average of two BP measurements at a single visit. A more precise estimate of BP levels would be obtained by multiple BP measurements obtained during several visits. Also, NHBPEP reference values were used to estimate the normal-high and elevated BP among Ghanaian children. [12] Nevertheless, these NHBPEP reference values have been adopted widely for different populations. [14] Various factors may also account for higher prevalence of high-normal and elevated BP among children such as an automated oscillometric device, as opposed to auscultatory mercury manometers. In this study, however, Omron M5-I device was used which has successfully passed the validation test in children.[27] Despite these shortcomings, the findings from this study are consistency with those of the adult studies,[4,5] and our results may well be representative of the Ashanti Region of Ghana as a whole and be reasonably used to formulate local health policy early in childhood. Also, because this study provides comprehensive assessment among children in three different localities, it should serve as a wake-up call for sub-Saharan Africa countries and other developing countries to step up cost-effective measures early in life to prevent double burden of diseases in adulthood.

Conclusion and implications

This study shows an increased in BP among these sub-Saharan African children in both rural and urban settings that confirm the higher prevalence of hypertension reported among adults. BP was associated with excess body weight in both boys and girls. These findings underscore the urgent needed for public health measures to prevent high BP and its sequelae from becoming another public health burden. In view of the scarcity of resources in Ghana as well as in many other developing nations, activities aimed at controlling elevated BP in children have to compete with many other pressing health needs. Nevertheless, long-term health risks for elevated BP in children can be considerable. It is therefore important that measures be taken to reduce these risks and optimize health outcomes for future generations. Reducing the mean population BP level by even as little as 2-3 mmHg could have a major impact in reducing associated morbidity.[28] This could be achieved by implementing cost-effective measures such as promotion of physical activity and reduction of salt intake through the school curriculum. Such measures will have a profound positive effect on high BP and will spare the next generation from a BP time bomb. This paper also calls for more work on BP in children in sub-Saharan African and other developing countries since higher BP is becoming major public health burden in many countries.

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Discussion

10

Discussion

In this final chapter, the summary of the key findings of various studies will be presented. It will also address some methodological issues concerning ethnicity and health, hypertension management, and implications of our findings.

Key Findings

Ethnic variations in blood pressure and prevalence of hypertension

Following systematic reviews, we found that the common perception that BP levels are higher in South Asian populations is unreliable - the picture is complex**.** Overall, BP were similar but there is stark heterogeneity within the South Asian groups, with slightly higher BP in Indians, slightly lower BP in Pakistanis, and much lower BP in Bangladeshis. South Asian men had a higher but women had a similar prevalence of hypertension compared with their White counterparts. Among African descent, BP levels and prevalence of hypertension were clearly higher among the older adults compared with their European White counterparts. Among younger African descent adults however, BP levels and prevalence of hypertension were similar to that of European White people. The finding of different patterns between the younger and the older adults led to an additional research question - Do variations in BP of ethnic minority children reflect those of the adult populations in the UK? The overall finding was that BP levels were similar across all ethnic groups in children in contrast with those in the corresponding adult populations in the UK where BP is comparatively high in those of the older African descent adults and comparatively low in those of Bangladeshi and Pakistani descent. The analyses of the SUNSET data showed a higher mean BP level and a higher prevalence of hypertension among both African Surinamese and Hindustanis compared with their White Dutch counterparts. There were no differences in awareness and pharmacological treatment of hypertension between the ethnic groups. African Surinamese hypertensive subjects however, were less likely to have their BP adequately controlled.

White-coat effect

Given the difficulty in explaining ethnic differences in BP and prevalence of hypertension, we assessed the possible contribution of the white-coat phenomenon on the differential ethnic risks and found no differences between people of African descent in both the UK and the USA and their European White counterparts. Contrary to expectations however, South Asian people had a lower white-coat effect than their White counterparts indicating that the slightly lower clinic BP in some South Asian populations such as Pakistanis and Bangladeshis might be partly caused by a low white-coat effect.

Nocturnal Blood pressure fall

A diminished nocturnal decline in BP has independently been associated with hypertension related complications including stroke, left ventricular hypertrophy, and progression of renal failure and therefore might contribute to ethnic differential risks in hypertension related complications. In our meta-analysis, we found a smaller percentage nocturnal BP decline and a higher prevalence of non-dipping among African descent populations in both the UK and the USA that may contribute to their higher hypertension related complications. South Asians had a higher nocturnal systolic BP fall but a similar diastolic BP nocturnal fall compared to Whites.

Factors associated with hypertension awareness, treatment and control in Ghana

Hypertension is becoming a major public health problem in sub-Saharan/Africa but awareness, treatment and control is lacking behind. Ascertaining factors associated with hypertension awareness, treatment and control is crucial in addressing this emerging problem. In our cross-sectional analyses from Ghana (West-Africa), we found that old age, inner city dwellers, and female sex were associated with higher awareness of hypertension. Old age, living in inner city, being a trader or obese person was associated with higher treatment of hypertension. Old age and only a primary school education were associated with inadequate BP control.

Blood pressure in rural, semi-urban and urban children in Ghana, West Africa

In children, BP tracking patterns confirm that persistent BP elevation may be related to hypertension in adulthood. Current evidence suggests that BP levels are rising among adults in the Sub-Saharan/ African region. In assessing BP profiles among children in a sub-Saharan African setting (Ghana), we found that considerable proportions of children had high-normal and elevated BP that confirmed the increasing prevalence of hypertension reported among adults. Blood pressure increased with increasing age in all sites. Rural children had lower BP levels than semi-urban and urban children. Blood pressure levels among Ghanaian children were similar to the current BP levels reported among African American and White American children, which contrast with lower levels reported among Ghanaian children in the 1970s.

General Discussion

Ethnic differences in disease experiences are not easily explained. Despite extensive research and widespread debate and speculations, very little is known of ethnic differential risks in hypertnsion.[1] Several potential explanations have been proposed, especially between African American and White American differences in BP and prevalence of hypertension. For example, genetic mechanisms have been used to explain familial aggregation of hypertension in Jamaican black people and the intra-class correlation of systolic BP amongst black twins[2,3] Low renin levels found in the African Americans have been hypothesised to be the result of a genetic 'mal-adaptation', which was thought to be beneficial to their earlier ancestors to survive the torment of a transatlantic passage under slavery, but later turned out to be harmful to survival due to the resultant avid salt retention.[4] In addition, increased sodium sensitivity, abnormalities in sodium transport, increased vascular responsiveness to pressor stimuli, association between stresses of low socio-economic status and hypertension, insulin resistance, and creatine kinase have also been proposed.[5] As the ethnic minority groups have higher levels of some indicators of stress,[6,7] it was expected that their alerting reaction is correspondingly higher in a clinical environment and could therefore contribute to the higher BP levels reported among some of ethnic groups. In an attempt to determine whether the white-coat phenomenon could contribute to these differential risks, we found no differences between African descent and their European White counterparts. South Asian populations contrary to expectation had a lower WCE as compared with their White counterparts. It seems improbable that ethnic differences in BP, particularly, the raised levels in people of African descent, are attributable to the white-coat phenomenon.

All available epidemiological evidence points to a combination of ill-defined underlying susceptibilities coupled with environmental exposures to salt and obesogenic influences as the key drivers of high BP.[8] Nevertheless, the extent to which each of these factors is attributed to ethnic differences in BP remain uncertain. The findings from this thesis and the emerging data[9-10] clearly show that there are substantial differences within each ethnic group indicating environmental and social importance of hypertension epidemiology. South Asian, African and European descent populations in different social settings show considerable variations in BP and prevalence of hypertension. Clear differences in BP and prevalence of hypertension were found within the South Asian descent populations in the UK, which highlight the importance of heterogeneity within this ethnic group.[11] The different mixes of Indians, Pakistanis and Bangladeshis in the study samples might contribute to the inconsistent results in the UK studies. Our findings also showed contrasting results between South Asian descent populations in the UK and those in the Netherlands. Contrary to the similar prevalence rates between South Asian and White women in the UK studies, Hindustani women in the Netherlands had a higher prevalence of hypertension compared with their White counterparts. On the other hand, the control of high BP among Hindustani people in the Netherlands is relatively favourable than for comparable South Asian groups in the UK. The differences in BP and hypertension patterns observed between South Asian descent populations in the Netherlands and those in the UK may reflect the substantial heterogeneity within these populations. Indeed, many South Asian populations in the UK are first generation migrants from the Indian subcontinent whereas those in the Netherlands are migrants from Surinam. Although they may share a common ancestry, they differ considerably in terms of culture, language, migration history, geographical locations, diet, and socio-economic positions, many of which are important determinants of high BP.[12]

Among people of African descent, different patterns also emerged from this thesis. Although BP levels and prevalence of hypertension were higher among the older African descent populations in the UK, USA and the Netherlands, among the young adults and children, BP levels showed different patterns between the UK and the USA studies. In the UK for example, BP levels among African descent young people and children were similar to that of their White counterparts. However, in the USA, BP levels are higher among African Americans at all ages compared with their White American counterparts. Also hypertension awareness, treatment and control vary within these groups. In the UK, hypertension awareness appeared to be higher among African Caribbean people than White people whereas hypertension control is similar between the groups. In the Netherlands, however, control of hypertension among African Surinamese men in particular is very low and is nowhere near the control rates reported among the African Americans in the USA. These different patterns observed among different African descent populations may reflect the substantial heterogeneity within these populations. African descent populations in Europe, as in the USA, are diverse but research into their health has yet to capture and capitalise on this. The African descent populations in Europe for instance, came mainly from ex-colonies and from the West Indies in the 1950s and 1960s.[13] African Americans however settled in the USA for more than two and a half centuries ago. These African groups are diverse in terms of beliefs, behaviours, risk factors, factors such as height and weight and disease experience.[14-17] For example, Fang et al studied the association between birthplace and mortality from cardiovascular causes in New York City, USA and showed variations between American born Black people and Caribbean born Black people exceeded those between Black and White people.[16] The International Collaborative Study on Hypertension in Blacks (ICSHB) study also showed a remarkable differences in prevalence of hypertension among seven populations of West African origin, ranging from 14.5% in Nigeria to 32.6% in Maywood, USA.[17] (figure 1)

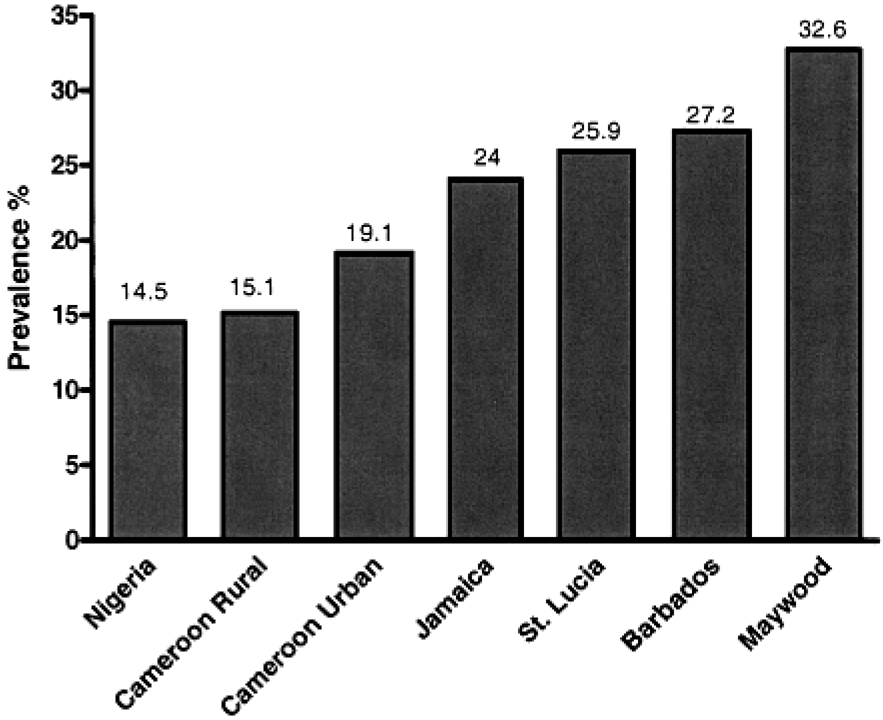

FIGURE 1 Age and sex-adjusted prevalence of hypertension among seven populations of West African origin: ICSHIB Study, 1995. Hypertension is defined as having BP ≥140/90 or medication.

Indeed, there are also substantial differences in BP and prevalence of hypertension within White European populations. A recent report by Cooper et al[9] addressed the issue of whether there is a truly genetic predisposition or whether perhaps an environmental influence is to blame for higher rates of prevalence of hypertension seen in some of these ethnic populations. They found a wide variation in prevalence of hypertension within both European and African descent groups, and the rates among African descent groups were not unusually high when compared internationally. They therefore suggest that the impact of environmental factors among African and European descent populations may have been under-appreciated. Contrary to expectations, the prevalence of hypertension was lower amongst the White peoples in USA and Canada, as compared to Europe (see figure below).

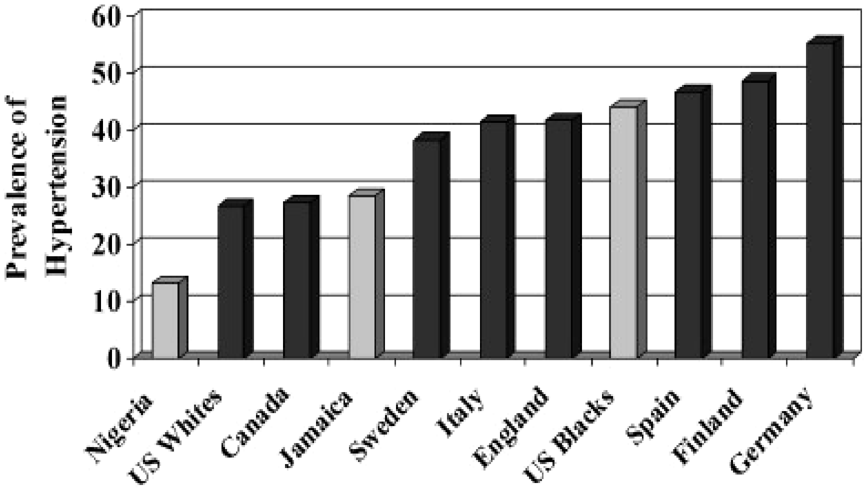

Figure 2 Age and sex adjusted hypertension prevalence among African and European Descent Populations
Source: Cooper et al. 2005

These substantial differences within similar populations as revealed by this thesis and others[9] seem to suggest that genetic factors have little to do with differences in BP and prevalence of hypertension within populations and highlight the importance of environmental factors. Presently, however, genetic factors have been placed at the top of the agenda to explain ethnic differences in BP at the expense of environmental factors.[1] The findings of this thesis challenge the 'geneticisation' of hypertension by ethnic groups and call for more attention on environmental and social factors including effect of discrimination on BP and hypertension. The findings of the differences within similar populations also suggest that inferences from cross-sectional studies done in certain geographic areas with different socio-economic background cannot be extrapolated as logical benchmarks for other areas. Clearly, there are important problems of excess disease and risks in some populations of African and South Asian descent, which cannot be uncovered and tackled properly if they are not studied, or the populations are lumped together as one homogeneous group. Thus, regular monitoring of cardiovascular risk factors is required in each geographical or social setting to determine how these risk factors may be changing overtime.

The cost of poor BP control is enormous. Uncontrolled hypertension is a serious risk factor for cardiovascular events such as stroke, heart failure, myocardial infarction and target-organ disease. Studies have shown that strict BP control significantly reduces the occurrence of these cardiovascular outcomes; by achieving the target of 140 mmHg, there would be a reduction of

28–44% in stroke and 20–35% in ischaemic heart disease depending on the age.[18] Unlike the results from molecular investigations, higher success rates have been achieved in the identification of important environmental factors in hypertension aetiology. Some of the important underlying risk factors include excess body weight; excess dietary salt intake, reduced physical activity, excess alcohol intake, and psychological stress.[19] Globally, WHO-ISH describes excess body fat as the most important factor predisposing individuals to primary hypertension.[20] Many of these factors are more common among ethnic minority groups. For example, overweight and obesity is very common among African descent populations especially in women, as this thesis has shown. Although overweight and obesity per se do not explain ethnic differences in BP and hypertension, it provides some explanation for shift in risk. The ICSHIB study among seven populations of West African origin showed the important role of BMI mediated exposures[17] (figure 3).

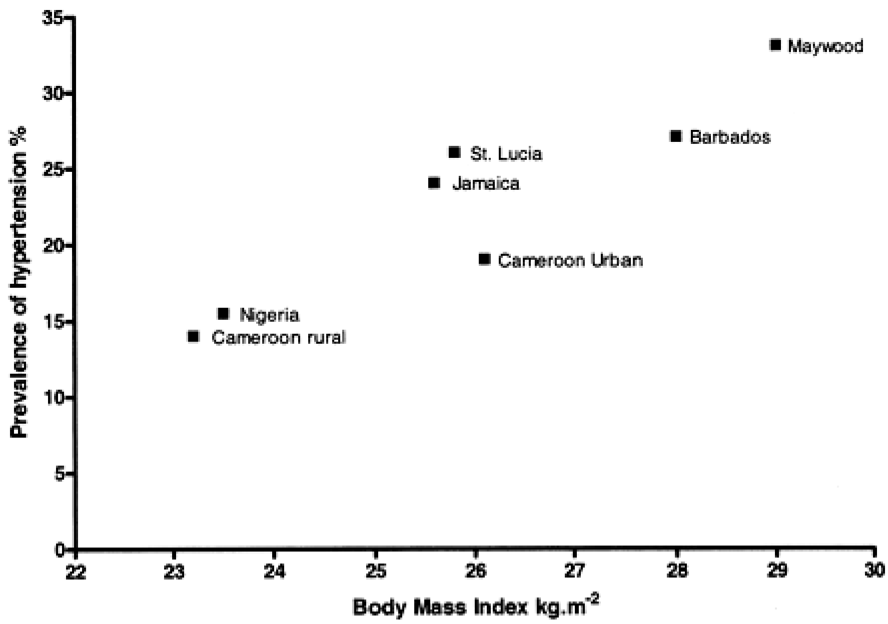

FIGURE 3 Prevalence of hypertension among seven populations of West African origin, by mean BMI: ICSHIB Study, 1995

Primary prevention measures targeting these underlying risk factors will have a major impact in reducing hypertension and its related complications. A population-based approach that decreases the BP level in the general population by even modest amounts has the potential to substantially reduce morbidity and mortality. For example, it has been estimated that a 5 mm Hg reduction of SBP in the population would result in a 14% overall reduction in mortality due to stroke, a 9% reduction in mortality due to CHD, and a 7% decrease in all-cause mortality[21] (see figure below)

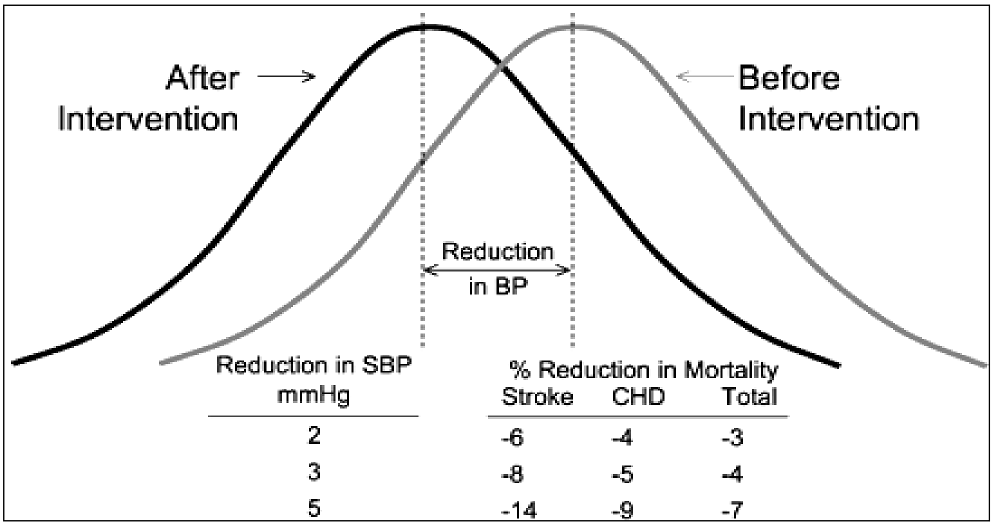

Figure 4 Systolic blood pressure distributions: Whelton PK et al. 2002

The epidemiological data provide plentiful evidence of the need for increasing awareness, and improving treatment and control of hypertension. Education of the general population using simple, action-oriented messages that identify the risks of untreated hypertension, the benefits and ease of appropriate treatment, and the positive consequences of a healthy lifestyle provide an important underpinning for efforts by health care professionals aimed at improving treatment and control of hypertension.[22]

Anti-hypertensive therapy is associated with reductions in stroke incidence averaging 35% to 40%; myocardial infarction, 20% to 25%; and heart failure, >50%.[23] Clinical trials mainly from the USA, suggest that anti-hypertensive therapy prevents hypertension sequelae in all ethnic groups.[1,24] Nonetheless, mono-therapy with BBs, ACEIs, or ARBs lowers BP to a lesser degree in African Americans compared with White Americans.[25-27] In the ALLHAT trial with more than 15 000 African Americans, the ACEIs were less effective in lowering BP than either the thiazide-type diuretic or the CCBs. This was associated with a 40% greater risk of stroke, 32% greater risk of heart failure, and 19% greater risk of CVD in those randomized to the ACEI versus the diuretic.[27] The ethnic differences in BP-lowering observed with these drugs were abolished when they were combined with a diuretic.[24,27] In some trials, when medications and provider services were provided free of charge as in the Hypertension Detection and Follow-up Program, African American men treated with the intensive "Stepped-Care Approach" actually benefited more than Whites.[28] Several other benefits of treatment have been demonstrated in minority populations. A 28% reduction in mortality was observed in African Americans who received BB therapy after acute myocardial infarction compared with those not receiving a BB.[29] Current evidence suggests however, that ethnic minority groups are under-represented in clinical trials especially in Europe.[30,31] Given a huge heterogeneity within these ethnic groups as demonstrated in this thesis, there is an urgent need to include ethnic minority groups in clinical trials to determine appropriate treatment regimes. In economically developing countries, however, given the high cost of hypertension medications relative to income, awareness and simple effective preventive measures represent the prime hope for reducing the impact of high BP on morbidity and mortality.

Implications for research and policy

This thesis clear shows that high BP is a serious problem in all ethnic groups with the rates being higher in older African descent people and South Asian men in the UK. The Netherlands data also show that prevalence and management of hypertension is an important public health problem especially in African Surinamese populations. These findings underscore the urgent need to develop strategies aiming at improving the prevention, treatment and control of hypertension among these ethnic groups in Europe. This will have a positive impact in reducing the higher levels of stroke, renal disease, and CHD morbidity and mortality among these ethnic minority groups in Europe. However, health prevention in ethnic minority groups is not straightforward and requires a major investment in studies within these groups to gain an understanding to help guide intervention efforts. Preventive and therapeutic strategies developed and tested in European populations may not apply to ethnic minority groups because of cultural differences, language barriers, poor education levels and poor social relations.[32] Strategies may have to be specifically developed, validated and assessed to consider both cultural acceptability, which is likely to affect uptake and compliance, and underlying susceptibility, which may affect the effectiveness of preventive and therapeutic options in different ethnic groups. Differences in health perception that may be attributable to differences in knowledge, beliefs and social circumstances need to be taken into account when designing preventative interventions in ethnic minority populations.[32] A qualitative study of Bangladeshis living in London, for example, found that both men and women viewed a large body size as being healthier than thinness. Exercise was not associated with health and fitness by the Bangladeshi men and women in that study and, in fact, it was believed it might exacerbate illness.[33]

On the whole, studies from the USA have demonstrated that elevated BP in childhood is a good predictor of elevated BP[34,35] in adulthood, and that there appear to be ethnic differences in BP trajectories, especially when multiple observations are available in both adolescence[36] and early adulthood.[34] Given the findings of this thesis that childhood BP patterns do not mirror those of adult BP in the UK ethnic groups, there is a need for a cohort study of children to investigate whether childhood BP trajectories predict hypertension in adulthood among the different ethnic groups in Europe. In the Netherlands, BP patterns among ethnic minority children are currently unknown. There is therefore an urgent need for BP studies among ethnic minority children to determine how these levels may be changing overtime. Since a growing proportion of people from ethnic minorities are second and third generation, epidemiological research among second and third-generation South-Asian and African descent populations is necessary to re-examine the prevalence of CVD risk factors and outcomes, to identify how disease patterns may be changing, so that appropriate interventions can be introduced early in life before unhealthy lifestyles become firmly established.

To answer definitively the question of whether some ethnic minority populations in Europe are more programmed to develop hypertension will require the availability of research data collected in such a way as to allow direct comparisons across populations in relation to susceptible factors and environmental exposure variables. In the absence of such data, we cannot state with confidence that some populations such as African or South Asian descent are either more susceptible or more exposed to influences that affect the development of high BP. There are still many uncertainties to the relative importance and contribution of environmental and genetic influences on the development of BP. However, there is now ample evidence to necessitate increased attention to investigating the non-genetic influences on BP, a deserted area of hypertensive research but perhaps a goldmine for establishing causal influences.[36] The future of hypertension research should focus on more standardised and comparable protocols, with comparable designs in data collection. Multi-centre data collection with a view to establishing local or national BP demographics is essential for the formal assessment of the global hypertension burden and the implementation of cost-effective primary preventive measures.

Future epidemiological studies should also recognise the heterogeneity within various ethnic groups and examine the subgroups separately to identify CVD risks specific to that group. Thus, in order to improve public health and epidemiological research in ethnicity and health and to facilitate international comparison, researchers need to move beyond the straightforward Black/White category that was the dominant and limiting approach for most of the twentieth century and access the considerable ethnic diversity that typify the population under study. As proposed for South Asian and White populations by Bhopal and colleagues elsewhere,[11,37] based on the evidence from this thesis we call for a debate on appropriate terminologies for African descent populations and concludes with the proposals that (a) describing the population under consideration is of paramount importance (b) the word African origin or simply African is an appropriate and necessary prefix for an ethnic label e.g. African Caribbean or African Kenyan (c) documents should define the ethnic labels (d) the label black should be phased out except when used in political contexts.

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Summary

Hypertension is a major risk factor for cardiovascular disease. The prevalence of hypertension, impact, and control differ across ethnic groups. In the United States, hypertension is more common, more severe, develops at an earlier age, and leads to more clinical sequelae in African Americans compared with White Americans. However, in Europe, notably the UK, ethnic differences in BP and prevalence of hypertension have not always shown consistent results. As ethnic minority populations in Europe are now ageing, the burden of cardiovascular disease is of prime importance. Detailed epidemiological information is critical for effective planning designed to improve population health.

The main objectives of this thesis were therefore to assess and provide epidemiological data on BP and hypertension among different ethnic groups in both adult and children with prime focus on European, African and South Asian descent populations; to provide epidemiological data on hypertension management and control among different ethnic groups, and to identify opportunities for appropriate prevention.

Chapter 1 introduces the background of this thesis. It describes the state of hypertension epidemics in the world stage and differences in BP and hypertension between ethnic groups. A brief introduction is given on terminology relating to race and ethnicity. The last section provides the specific aims and outline of this thesis.

Chapter 2 and 3 describe systematic reviews on BP and prevalence of hypertension among African and South Asian descent populations in comparison with European descent populations. The results of the reviews show that the common perception that BP levels are higher in South Asians is unreliable. Overall, BP levels were similar but there was stark heterogeneity in the South Asian groups, with slightly higher BP in Indians, slightly lower BP in Pakistanis, and much lower BP in Bangladeshis. South Asian men, however, had a higher prevalence of hypertension compared with White men (Chapter 2). Among African descent populations, BP levels and prevalence of hypertension were clearly higher among the older adults compared with their European White counterparts. Among African descent younger adults however, BP levels and prevalence of hypertension were similar to that of White people.

In Chapter 4, following the unexpected finding of similar BP levels and prevalence of hypertension among younger adults we conducted an additional systematic review on BP among children. The overall finding was that BP levels were similar across all ethnic groups. These similarities in BP patterns particularly in African, Bangladeshi and Pakistani descent children contrast with those in the corresponding adult populations in the UK where BP is comparatively

high in those of African descent and comparatively low in those of Bangladeshi and Pakistani descent.

Chapter 5 describes the results of a meta-analysis on ethnic differences in white-coat effect. As the ethnic minority groups have higher levels of some indicators of stress, it was expected that their alerting reaction is correspondingly higher in a clinical environment. The study results however, showed no difference in white-coat effect between African and European descent groups in both the UK and the USA. South Asian people on the contrary, had a lower white-coat effect than their European counterparts. It seems improbable that ethnic differences in BP, particularly, the raised levels in people of African descent are attributable to the white-coat phenomenon but the slightly lower clinic BP in some South Asian populations such as Pakistanis and Bangladeshis might be partly caused by a low WCE.

Chapter 6 describes the results of a meta-analysis on ethnic differences in nocturnal BP fall. The results showed a smaller percentage nocturnal BP decline and a higher prevalence of non-dipping among African descent populations in both the UK and the USA. South Asians had a higher nocturnal systolic BP fall but a similar nocturnal diastolic BP fall compared to Whites. The higher prevalence of non-dipping among African descent populations may contribute, at least in part, to the comparatively high cardiovascular morbidity and mortality that are not explained by casual clinic BP. South Asians of Bangladeshi and Pakistani origins have comparatively high stroke mortality rates that are not explained by their BP, nor by a lack of nocturnal BP falls.

Chapter 7 reports on prevalence of hypertension, awareness, treatment and control among Dutch ethnic groups in South-east Amsterdam, the Netherlands. The findings show that hypertension is a serious problem in Dutch minority ethnic groups. Nearly 47% of African Surinamese and 42% of Hindustanis were hypertensive compared with 33% of the White Dutch people. There were no differences in awareness and pharmacological treatment of hypertension between the groups. African Surinamese hypertensive men 0.3 (0.1 to 0.7; $P<0.01$) and women 0.5 (0.3 to 0.9; $P<0.05$) were less likely to have their BP adequately controlled compared with White Dutch people. These findings underscore the urgent need to develop strategies aiming at improving the prevention and control of hypertension especially among African Surinamese people in the Netherlands.

Chapter 8 reports on factors associated with hypertension awareness, treatment and control among adults in the Ashanti region of Ghana, West Africa. It was found that 29.4% of the study participants were hypertensive. Of these, 34% were aware of their condition, 28% were receiving treatment, and 6.2% were controlled. Old age, living in inner city and a female sex were associated with increased awareness of hypertension. Old age, living in inner city, being a trader or obese person was associated with higher levels of treatment for hypertension. Among all hypertensive subjects, being a trader or a smoker were associated with adequate BP control. Among those on hypertension medication, old age and a primary school education was associated with inadequate BP control. The identified factors provide important information for improving BP control among this population. Given the high cost of hypertension medication relative to income, increasing awareness and simple preventive measures such as promotion of physical activity, normalising body weight and reduction of salt intake, present the best hope for reducing the impact of hypertension on morbidity and mortality.

In chapter 9, we present results on BP patterns among rural, semi-urban and urban children in Ghana, and compare our results with that of African American and White American children in the United States to assess how BP levels may be changing over time. In all study areas, BP increased with increasing age in both boys and girls. Blood pressure levels were lower in rural settings than in semi-urban and urban settings. Excess body weight was independently associated with systolic and diastolic BP in both boys and girls. Considerable proportions of Ghanaian children had high-normal and elevated BP levels compared with the NHBPEP reference values. Blood pressure levels among Ghanaian children were similar to the current BP levels reported among White and African American children, which contrast with lower levels reported among Ghanaian children in the 1970s. The high BP levels found among these Ghanaian children confirm the higher prevalence of hypertension reported among adults. Cost-effective public health measures are urgently needed to spare the next generation from future increases of cardiovascular morbidity.

In the general discussion (Chapter 10), issues related to hypertension control and heterogeneity within ethnic groups is discussed. It is concluded that the higher prevalence of hypertension among ethnic minority groups in Europe underscore the urgent need to develop strategies aiming at improving the prevention, treatment and control of hypertension among these ethnic groups. However, health prevention in ethnic minority groups is not straightforward and requires a major investment in studies within these groups to gain an understanding to help guide intervention efforts. The future of hypertension research should focus on more standardised and comparable protocols, with comparable designs in data collection. Studies should also recognise the heterogeneity within various ethnic groups and examine the subgroups separately to identify CVD risks specific to that group.

Samenvatting

Hypertensie is een belangrijke risicofactor voor cardiovasculaire ziekten. De prevalentie van hypertensie, de impact en controle verschillen tussen etnische groepen. In de Verenigde Staten komt hypertensie meer voor bij Afrikaanse Amerikanen dan bij Blanke Amerikanen. Ook is de hypertensie bij hen ernstiger, ontstaat op jongere leeftijd en leidt tot meer klinische complicaties. In Europa echter, met name in het Verenigd Koninkrijk, zijn de verschillen in bloeddruk en prevalentie van hypertensie niet altijd eenduidig. Aangezien mensen van etnische minderheidsgroepen in Europa steeds ouder worden, is het probleem van cardiovasculaire aandoeningen belangrijk. Gedetailleerde epidemiologische informatie is essentieel voor effectieve planning van de verbetering van de volksgezondheid.

De belangrijkste doelstellingen van dit proefschrift waren daarom het bestuderen en genereren van epidemiologische gegevens over bloeddruk en hypertensie in verschillende etnische groepen onder volwassenen en kinderen met name in groepen van Europese, Afrikaanse en Zuid Aziatische afkomst; het verschaffen van epidemiologische gegevens over behandeling en controle van hypertensie in verschillende etnische groepen en het identificeren van passende preventiemogelijkheden.

Hoofdstuk 1 introduceert de achtergrond van dit proefschrift. De wereldwijde epidemieën in hypertensie worden beschreven evenals de verschillen tussen etnische groepen. Een korte inleiding volgt over de begrippen ras en etniciteit. Het laatste deel beschrijft de specifieke doelen en de opzet van dit proefschrift.

Hoofdstuk 2 en 3 beschrijven systematische reviews van bloeddruk en prevalentie van hypertensie onder Afrikaanse en Zuid Aziatische bevolkingsgroepen vergeleken met populaties van Europese afkomst. De uitkomsten van de reviews laten zien dat de algemene opvatting dat bloeddrukwaarden hoger zijn in Zuid Aziaten niet klopt. Over het algemeen waren bloeddrukwaarden gelijk maar er was veel heterogeniteit in de Zuid Aziatische groepen, met iets hogere bloeddruk in Indiërs, iets lagere bloeddruk in Pakistanen en veel lagere bloeddruk in mensen afkomstig uit Bangladesh. Maar de prevalentie van hypertensie in Zuid Aziatisch mannen was hoger dan in blanke mannen (hoofdstuk 2). Bij oudere volwassenen van Afrikaanse afkomst waren bloeddrukwaarden en prevalenties van hoge bloeddruk duidelijk hoger dan bij oudere volwassenen van blank Europese afkomst. Bij jong volwassenen van Afrikaanse afkomst, waren bloeddrukwaarden en prevalenties van hypertensie echter gelijk aan die van blanken.

Vanwege de onverwachte bevinding dat bloeddrukwaarden en prevalenties van hypertensie vergelijkbaar waren in jong volwassenen, hebben we in hoofdstuk 4 nog een systematische review

verricht van bloeddruk in kinderen. De algemene uitkomst was dat bloeddrukwaarden vergelijkbaar waren in alle etnische groepen. Deze overeenkomsten in bloeddrukwaarden, vooral in kinderen van Afrikaanse, Bengaalse en Pakistaanse afkomst is in tegenspraak met de overeenkomstige volwassen populaties in het Verenigd Koninkrijk waarin de bloeddruk relatief hoog is in mensen van Afrikaanse afkomst en laag in mensen van Bengaalse en Pakistaanse afkomst.

Hoofdstuk 5 beschrijft de resultaten van een meta-analyse van etnische verschillen in *white coat hypertension.* Omdat etnische minderheden hoger scoren op bepaalde stress indicatoren, was de verwachting dat zij ook vaker een stress reactie tonen in een klinische omgeving. De studieresultaten toonden echter geen verschil aan in *white coat effect* tussen groepen van Afrikaanse en Europese afkomst in zowel het Verenigd Koninkrijk als de VS. Integendeel; Zuid Aziaten hadden een lager *white coat effect* dan hun Europese tegenhangers. Het lijkt onwaarschijnlijk dat etnische verschillen in bloeddruk te wijten zijn aan het *white coat* fenomeen. Dit geldt met name wat betreft de verhoogde bloeddruk in mensen van Afrikaanse afkomst, hoewel de iets lagere bloeddruk in sommige Zuid Aziatische bevolkingsgroepen, zoals Pakistanen en Bengalen, voor een deel veroorzaakt zou kunnen worden door een gering *white coat effect.*

Hoofdstuk 6 beschrijft de resultaten van een meta-analyse van etnische verschillen in nachtelijke bloeddrukdaling. De resultaten toonden een kleiner percentage nachtelijke bloeddrukdaling en een hogere prevalentie van *non-dipping* onder bevolkingsgroepen van Afrikaanse afkomst in zowel het Verenigd Koninkrijk als de Verenigde Staten. Zuid Aziaten hadden een grotere systolische bloeddrukdaling maar een vergelijkbare diastolische bloeddrukdaling vergeleken met Blanken. De hogere prevalentie van *non-dipping* onder bevokingsgroepen van Afrikaanse afkomst draagt mogelijk, tenminste voor een deel, bij aan de relatieve hoge cardiovasculaire morbiditeit en mortaliteit die niet verklaard kunnen worden door de random klinische bloeddruk. Zuid Aziaten van Bengaalse en Pakistaanse afkomst hebben relatief hoge Cerebro Vasculair Accident (CVA) mortaliteitscijfers die niet verklaard kunnen worden door hun bloeddruk, noch door een gebrek aan nachtelijke bloeddrukdalingen.

Hoofdstuk 7 rapporteert over prevalenties van hypertensie, het zich bewustzijn zijn van hypertensie, behandeling en controle onder Nederlandse etnische groepen in Zuid-oost Amsterdam, Nederland. De resultaten laten zien dat hypertensie een serieus probleem is onder Nederlandse etnische minderheden. Bijna 47% van Afrikaanse Surinamers en 42% van Surinaamse Hindoestanen hadden hypertensie vergeleken met 33% van de Blanke Nederlanders. Er waren geen verschillen in bewustzijn van hypertensie en farmacologische behandeling van hypertensie tussen de groepen.

Afrikaans Surinaamse mannen en vrouwen met hypertensie hadden hun bloeddruk minder vaak adequaat behandeld vergeleken met blanke Nederlanders (mannen 0,3 [0,1 - 0,7]; p = 0,01 en vrouwen 0,5 [0,3 - 0,9]; p = 0,05). Deze resultaten benadrukken de dringende noodzaak om strategieën te ontwikkelen voor de preventie en controle van hypertensie, met name onder Afrikaanse Surinamers in Nederland.

Hoofdstuk 8 rapporteert over factoren die geassocieerd zijn met het zich bewust zijn van hypertensie, behandeling en controle onder volwassenen in de Ashanti regio van Ghana, West Afrika. Van de deelnemers aan de studie bleken 29,4% hypertensie te hebben. Van hen waren 34% zich hiervan bewust, 28% werden behandeld en 6,2% waren adequaat behandeld. Oudere leeftijd, in de binnenstad wonen en van het vrouwelijke geslacht zijn waren geassocieerd met een toename van het zich bewust zijn van de hypertensie. Oudere leeftijd, in de binnenstad wonen, een handelaar zijn en obesitas waren geassocieerd met adequaat behandelde bloeddruk. Onder degenen die anti-hypertensiva ontvingen waren oudere leeftijd en een lagere school opleiding geassocieerd met adequaat behandelde bloeddruk. De geïdentificeerde factoren bieden belangrijke informatie om bloeddrukcontrole te verbeteren in deze populatie. Gezien de hoge kosten van anti-hypertensiva in verhouding tot het inkomen, bieden het vergroten van kennis en eenvoudige preventieve maatregelen, zoals het stimuleren van fysieke beweging, normalisering van het lichaamsgewicht en het reduceren van zoutinname, de beste hoop voor het verminderen van de impact van hypertensie op morbiditeit en mortaliteit.

In hoofdstuk 9 presenteren we de resultaten van bloeddrukverschillen onder kinderen in Ghana op het platteland, in verstedelijkt gebied en in de stad en vergelijken we onze resultaten met die van Afrikaans Amerikaanse en Blank Amerikaanse kinderen in de Verenigde Staten om te bepalen hoe bloeddrukwaarden mogelijk veranderen in de loop van de tijd. In alle onderzoeksgebieden nam de bloeddruk toe met toenemende leeftijd in zowel jongens als meisjes. Bloeddrukwaarden waren lager op het platteland dan in verstedelijkt gebied en in de stad. Overgewicht was onafhankelijk geassocieerd met systolische en diastolische bloeddruk in zowel jongens als meisjes. Een vrij groot deel van de Ghanese kinderen had hoog-normale en verhoogde bloeddrukwaarden vergeleken met de NHBPEP referentie waarden. Bloeddrukwaarden onder Ghanese kinderen waren vergelijkbaar met de huidige bloeddrukwaarden die gevonden worden onder Blanke en Afrikaans Amerikaanse kinderen, wat in contrast is met de lagere waarden die gerapporteerd zijn onder Ghanese kinderen in de jaren ´70. De hogere bloeddrukwaarden die onder deze Ghanese kinderen gevonden werden bevestigen de hogere prevalentie van hypertensie die onder volwassenen is gerapporteerd. Kosten-effectieve public health maatregelen zijn dringend nodig om de volgende generatie toekomstige toenames in cardiovasculaire morbiditeit te besparen.

De algemene discussie (Hoofdstuk 10) bespreekt thema´s die gerelateerd zijn aan de controle van hypertensie en heterogeniteit binnen etnische groepen. De conclusie is dat de hogere prevalentie van hypertensie onder etnische minderheidsgroepen in Europa de dringende noodzaak onderstrepen om strategieën te ontwikkelen gericht op het verbeteren van preventie, behandeling en controle van hypertensie onder deze etnische groepen. Echter, gezondheidsvoorlichting in etnische minderheidsgroepen is niet eenvoudig en vereist een enorme investering in studies onder deze groepen om meer inzicht te verkrijgen en om richting te geven aan interventiestrategieën. Toekomstig onderzoek naar hypertensie zou gericht moeten zijn op meer gestandaardiseerde en vergelijkbare protocollen, met vergelijkbare opzet van data verzameling. Studies zouden ook de heterogeniteit binnen verschillende etnische groepen moeten erkennen en de subgroepen apart moeten onderzoeken om de risico's voor hart- en vaatziekten (HVZ) te identificeren die specifiek zijn voor elke groep.

Acknowledgements

The writing of this thesis would never have been achieved without the support of many significant others. I am very much indebted to my supervisors, study participants, nurses, colleagues, and my family for all the support they provided for writing this thesis.

Indeed there are special names that need to be mentioned.
Prof. Raj Bhopal (Bruce and John Usher Professor of Public Health, University of Edinburgh) supervised my Master's degree in Public Health in Edinburgh. Although I did my Master's degree alongside a full-time job, your advice, support and excellent coaching resulted in distinction in my MSC thesis. You continued to coach me even after my MSc and agreed to supervise this thesis. I have learnt a lot from you Raj, which undoubtedly will guide me in many years to come. I owe you a lot but nothing can substitute the knowledge that you have given me, so all I can say now is THANK YOU VERY VERY MUCH!

I am also heavily indebted to Dr Marc Bruijnzeels for given me the great opportunity to write this thesis under his supervision. I have learnt a lot from you Marc and it was always a pleasure to come to see you for advice and discussion of papers. THANK YOU SO MUCH!

I very much like to thank Dr Karien Stronks (AMC University, Amsterdam?), Dr Ken Redekop (Erasmus MC) and Dr Cruickshanks (Manchester University, UK) for all their advice and support, and more importantly their time for providing very useful comments on many papers.
To my parents, I am very much indebted for their support and unconditional love.

I would like to thank the REACH team (both old and new members) for all their excellent support and comments.

Ank, where should I begin - my biggest and most reliable critic! You have been wonderful in every phase of this thesis; you have always provided excellent criticism, suggestions and support, and your approval always meant a lot to me. Above all, you have always shown unconditional love throughout this work. Your family, especially your parents (Mr/s de Jonge), have always been great in supporting and encouraging me throughout this thesis. I am very grateful to them

Finally, I apologise to those I have not mentioned by name. They are not forgotten. Thank you all very much.

About the Author

Charles Agyemang was born in 1968 in Kumasi, Ghana. After School, Charles moved to the UK to joined family and to further his education. After spending one year at Brunel University, London to study Business administration, Charles realised that that was not for him. He then switched to health studies in Edinburgh. In 1998, he obtained BSc with distinction in health studies. He worked at Lothian University Trust (Edinburgh Royal infirmary) for nearly five years. In 1999, he obtained admission to study Masters in Public Health at University of Edinburgh Medical School. In 2001 he received a master degree in Public Health under the supervision of Professor Raj Bhopal (Bruce and John Usher Professor of Public Health). In 2003, he moved to the Netherlands to join his partner and to work as research scientist at the Department of Health Policy and Management, Erasmus Medical Centre, the Netherlands. He is currently working for the National Institute of Public Health and the Environment (RIVM).