

An International Comparative Study of Blood Pressure in Populations of European vs. African Descent

Richard S. Cooper¹, Katharina Wolf-Maier¹, Amy Luke¹, Adebowale Adeyemo²,
José R. Banegas³, Terrence Forrester⁴, Simona Giampaoli⁵, Michel Joffres⁶, Mika
Kastarinen⁷, Paola Primatesta⁸, Birgitta Stegmayr⁹, Michael Thamm¹⁰

¹ Department of Preventive Medicine and Epidemiology, Loyola University Stritch School of Medicine, Maywood, IL

² Department of Pediatrics, University College Hospital, Ibadan, Nigeria

³ Departamento de Medicina Preventiva y Salud Pública, Facultad de Medicina. Universidad Autónoma de Madrid, Spain

⁴ Tropical Medicine Research Institute, University of the West Indies, Kingston, Jamaica

⁵ Istituto Superiore di Sanità, Laboratorio di Epidemiologia e Biostatistica, Rome, Italy

⁶ Department of Community Health and Epidemiology, Faculty of Medicine, Dalhousie University, Halifax, Nova Scotia

⁷ Department of Public Health and General Practice, University of Kuopio, Finland

⁸ Department of Epidemiology and Public Health, University College London Medical School, London, UK

⁹ Department of Medicine, University Hospital, Umeå, Sweden

¹⁰ Robert-Koch Institut, Berlin, Germany

Direct correspondence to:

Dr. Richard Cooper, Department of Preventive Medicine and Epidemiology, Loyola University Stritch School of Medicine, 2160 S. First Ave, Maywood, IL 60153
Phone: 708-327-9018 Fax: 708-327-9009 E-mail: rcooper@lumc.edu

Keywords: *Hypertension, Prevalence, Blacks, Whites*

Abstract

Background: The consistent finding of higher prevalence of hypertension in US blacks compared to whites has led to speculation that African-origin populations are uniquely susceptible to this disease. Large surveys now provide new information on this issue.

Methods: Using a standardized analysis strategy we examined prevalence estimates for 8 white and 3 black populations (N = 85,000 participants).

Results: The range in hypertension prevalence was from 27 to 55% for whites and 14 to 44% for blacks.

Conclusions: These data demonstrate that not only is there a wide variation in hypertension prevalence among both racial groups, the rates among blacks are not unusually high when viewed internationally. These data suggest that the impact of environmental factors among both populations may have been under-appreciated.

Introduction

Population surveys in the US from early in the last century have consistently documented higher blood pressures and related cardiovascular sequelae in blacks compared to whites (1,2). The enormous attention focused on this observation has resulted in a dichotomous view of hypertension risk - populations of African origin are considered more susceptible than all other continental groupings and a strong genetic hypothesis of inherent predisposition to hypertension among blacks has become the conventional wisdom (3-5). Since this research has been limited primarily to the US, the generalizability of these conclusions is open to question. An important piece of evidence that has been missing from this debate is data on the prevalence of hypertension in other genetically-related populations of African and European descent.

International comparative studies on hypertension have been seriously limited by the absence of a valid method of standardization. In the last decade, however, high quality population surveys have been conducted in a wide range of populations that used either careful internal standardization or sufficiently comparable methods (6-15). We report here on the patterns of hypertension prevalence in a sample of 4 such surveys among blacks from Africa, the Caribbean and the US and 8 surveys among whites from the US, Canada and Europe.

Methods

Study Design

Black populations were drawn from the International Collaborative Study on Hypertension (ICSHIB) and the National Health and Nutrition Survey III (6,16). A

primary report of ICSHIB demonstrated a gradient in hypertension risk from east to west, parallel to the gradient in socioeconomic development and the associated lifestyle (6). An extensive process of cross-standardization was incorporated into ICSHIB to insure that measurement technique did not bias the survey results (7). We subsequently identified surveys on hypertension conducted since 1990 that were national in scope in North America and Europe. Two North American and six European surveys were included, viz: USA (8) and Canada, (9), England (10), Finland (11), Germany (12), Italy (13), Spain (14) and Sweden (15). The US data from NHANES-III are available for public use through the National Center for Health Statistics (8). Investigators in Canada and Europe were contacted and invited to join this project. More detailed methods of this component of the study have been reported earlier (16). In brief, after achieving consensus on the main goals and resolving the methodological issues data collection forms were distributed. Each collaborator provided average gender- and age-specific data by 5-year age groups for BP's, body mass index (BMI), and counts of hypertensives by treatment and control status. A description of the key aspects of each survey, including the BP measurement procedure, was collected in a standardized format.

The surveys that formed the basis of ICSHIB were conducted in localized communities by door-to-door screening (6,7). The studies of the European-origin populations and African Americans were larger in scope (16). Some were based on a random probability sample of the entire nation, while others were a series of regional samples; none were restricted mainly to a single province or sub-region within the country (Appendix Table). Collectively the studies enrolled 85,000 participants and the

number of subjects in individual studies ranged from 1,800 to 23,000. Participation rates varied from 61% to 82%. Sampling was conducted mainly on population registries.

Data Collection Methods

The examination methods have been reported in detail previously (6,7,16). In brief, the mercury sphygmomanometer was used for BP measurements in every country except England, where the Dinamap 8100 oscillometric device was used. All studies had at least 2 measurements and the 2nd BP from the clinic visit was used to create the mean for the age-gender groups, except for England where the 2nd home BP was used. Hypertension was defined as BP \geq 140/90 mmHg or current use of antihypertensive medication.

Data Analysis

BP, body mass index (BMI), and hypertension prevalence were calculated for 5-year age-gender groups and aggregated as the primary data file. To achieve maximum overlap we restricted the analysis to 35-74 years for age-specific estimates of BP and hypertension prevalence, and 35-64 years for age-adjusted results. In the US NHANES whites and blacks were analyzed separately with the appropriate weighting for population size. As previously reported, the prevalence estimates obtained for US blacks from ICSHIB were virtually identical to those from NHANES (6); to enhance generalizability, however, we used the NHANES data to represent the US black population. Hypertension prevalence and control was age-adjusted by age-averaging

the 5-year age groups combining the data for men and women. For comparison of all white vs. all black populations the mean BP's and prevalences were averaged, considering each country as a single unit (i.e., without weighting by population size).

Results

Patterns of blood pressure

The age-averaged BP's and BMI's are presented for each survey, by gender, in Table 1. It must be recognized that where treatment is common these data may understate the true values, although this effect is likely to be small when the population is considered as a whole. Trends in blood pressure with age showed considerable heterogeneity within both continental population groups (Figures 1,2). In rural Nigeria mean blood pressures were low and rose only modestly with age (Figure 1).

Intermediate levels of BP were observed in Jamaica, while the US blacks had higher BP's at all ages. As previously reported, whites in the US and Canada had substantially lower BP's over the entire life span than did the Europeans (Figure 2). For greater clarity, the age-specific patterns are presented for all black and all white groups combined (Figure 3).

Hypertension prevalence

Hypertension prevalence, which accounts for the effect of treatment, follows a similar pattern although the east-west gradient among the African-origin groups is more consistent (Table 2, Figure 4). Among the 14 populations, US blacks fall near the middle in terms of prevalence (mean prevalence = 37%, U.S. blacks = 44%). Among

those above the mean, all but one is of European origin. Important differences are apparent in the gender-specific prevalence hypertension in these groups. Among Jamaican women hypertension was substantially more common than among Jamaican men (32% vs. 23%), and relative gender equality existed for US blacks. In Europe, however, the prevalence of hypertension was higher among men in every country (range 5-10%).

Hypertension prevalence and obesity

The only etiologic factor on which standardized information was available was obesity, measured by its proxy BMI. The correlation between average BMI and hypertension prevalence was 0.6 ($p < .01$), all populations combined. Within the black populations the same correlation was observed between mean BMI's and hypertension prevalence ($r = 0.6$). Among whites, however, the relationship was much less apparent ($r = 0.3$). Of course, since obesity will be correlated with many other aspects of lifestyle it is difficult to conclude whether weight gain itself is playing a less important role in determining the variation among white populations. The contrasts noted above in hypertension prevalence by gender are consistent with the relative excess of obesity in women compared to men among Jamaicans and US blacks (2,6).

Discussion

Comparisons of BP distributions across populations are made difficult by the requirement of comparability of the survey methods. In the last 2 decades, however, adoption of standardized protocols along with rigorous training have greatly improved

the quality of epidemiologic studies of hypertension (6,17-19). A number of countries now conduct recurring national surveys that monitor both secular trends and regional variation within the country (10-12,19,20). While independent surveys from the same base population had given divergent results in the past, at least two recent single-community studies conducted in the US provided estimates virtually identical to NHANES (21,22). Although this evidence does not diminish the requirement of careful assessment of survey methodology before making comparisons, it does demonstrate that reliable information can be obtained from independent studies.

The data presented here demonstrate a two-fold variation in prevalence of hypertension in both European- and African-origin populations. The prevalences are similar in US blacks and European whites, although important gender differences are apparent. Although not a systematic sample, the populations that are included generally reflect the characteristic social setting in which these groups are found around the world. Summed across all groups, the white populations on average have a substantially higher burden of hypertension. This result can be attributed in large part to the inclusion of several black samples from developing countries where risk factors for hypertension are present at a lower level. In the only head-to-head comparison within the same survey US blacks have a prevalence that is 50% higher than among whites. Data from the UK, including the national survey, also demonstrate higher BP's and more hypertension among blacks of Caribbean and African descent (23-27). On the whole, however, the published literature on racial disparities in hypertension from the UK is less consistent than in the US, where essentially every study has reported higher

rates among blacks (28). Surveys from Cuba, Trinidad and Brazil have also shown a smaller black-white gradient in BP than found in North America (29-31).

Are these findings merely artifactual, reflecting either methodologic error or the sampling process? The most unexpected feature of the data presented here are the high rates of hypertension in Europe, when contrasted to whites in Canada and the US. These results have been reported in greater detail in an earlier publication (16). It is beyond the usual standard of statistical significance for the 6 European surveys to be higher by chance than both of those in North America ($p < .05$). As previously demonstrated, mortality rates for stroke - the most sensitive vital statistics indicator of uncontrolled high BP - are strongly correlated with the prevalence of hypertension among these countries ($r = 0.8$) (16). Although the data are more limited, hypertension appears to be even more common in Eastern Europe (32-34). In a comparison of POLMONICA with the US-based ARIC study, systolic BP's in Poland were 20 mmHg higher than in the US (3).

The primary purpose of this analysis was to provide descriptive results and very limited information was available on factors that might explain the findings we observed. The gradient among the black populations is consistent with the transition to an industrialized lifestyle and is thereby collinear with most known risk factors (6). BMI is serving as an effective proxy for this relationship, although its independent contribution cannot be quantified. The explanation of the European-North American contrasts among the white populations is not as apparent. As we have discussed elsewhere, either known risk factors other than obesity are having a larger impact at the population

level than usually appreciated, or unknown factors are at work (16). In either case, further examination of this question seems justified.

Treatment guidelines and practice patterns vary widely among these countries (16-19). Widespread treatment could, of course, alter the mean BP's in a population, although this effect would be confined to persons over 55 where hypertension is common. The US has the highest rate of treatment, with about 25% of hypertensives controlled, compared to 10% in Europe and less than 1% in Africa (with hypertension defined as 140/90 mmHg)(16). Any biases that would be introduced into the cross-national comparisons by differential treatment and control are insufficient to alter the primary conclusions, however. The virtual absence of treatment in rural Africa would mean that the natural distribution has essentially been observed unaltered. The effect of treatment in the US or Canada would not be apparent in younger individuals, where BP's contrasts with Europe and Africa are equally large.

If the large North American-European contrasts are occurring in genetically homogeneous populations, large environmental influences must be at work that are not apparent on the surface. A similar process could be taking place across the social environments into which persons of African origin are assorted within societies such as the US and the UK. The debate over inherent susceptibility cannot be resolved with these data since neither the genetic or environmental influences can be held constant, allowing a test of the relative influence of the other factor. In fact, the question of inherent susceptibility is probably non-testable under any circumstances (35,36). While the assumption is often made that contrasting environmental influences between blacks and whites can be adjusted by using proxy measures such as education, that

assumption does not hold up under close examination (37). Perhaps more to the point, however, these data demonstrate that the consistent emphasis given to the genetic elements of the racial contrasts may be a distraction from the more relevant issue of defining and intervening on the preventable causes of hypertension, which are likely to have a similar impact regardless of ethnic and racial background (38). Once the problem of ethnic/racial contrasts is characterized more closely as a special instance of environmental influences at the population level it could become more tractable in both the realms of research and practice.

Competing Interest: none declared

Authors' Contributions:

RC, KWM, AL and JB were responsible for study concept, design and supervision. RC, KWM, JB, SG, MJ, AA, TF MK, PP, BS and MT were involved in data acquisition. RC, KWM, JB, MJ, PP and AL were responsible for analysis and interpretation of data. RC and KWM drafted the manuscript. RC, JB, SG, AL, AA, TF, MJ, MK, PP, BS and MT were involved in critical revision of the manuscript for important intellectual content. Statistical expertise was provided by MJ. Administrative, technical and material support was provided by KWM, MK, and BS.

Acknowledgements:

The authors are grateful for the use of the data from the Osservatorio Epidemiologico Cardiovascolare, Italy. We would like to thank Guichan Cao for assistance in data management and analysis at Loyola University.

Sources of funding: Centers for Disease Control and Prevention, USA

References:

1. Lackland DT, Keil JE: **Epidemiology of hypertension in African Americans.** *Semin Nephrol.* 1996, **16**:63-70.
2. Cooper R, Rotimi C: **Hypertension in blacks.** *Am J Hypertens* 1997, **10**:804-812.
3. Cooper RS, Rotimi C: **Hypertension in populations of West African origin: Is there a genetic predisposition?** *J Hypertens* 1994, **12**:215-227.
4. Brewster LM, Clark JF, van Montfrans GA: **Is greater tissue activity of creatine kinase the genetic factor increasing hypertension risk in black people of sub-Saharan African descent?** *J Hypertens* 2000, **18**:1537-1544.
5. Grim CE, Robinson M: **Blood pressure variation in blacks: genetic factors.** *Semin Nephrol* 1996, **16**:83-93.
6. Cooper R, Rotimi C, Ataman S, McGee D, Osotimehin B, Kadiri S, Muna W, Kingue S, Fraser H, Forrester T, Bennett F, Wilks R: **Hypertension prevalence in seven populations of African origin.** *Am J Public Health* 1997, **87**:160-168.
7. Ataman SL, Cooper R, Rotimi C, McGee D, Osotimehin B, Kadiri S, Kingue S, Muna W, Fraser H, Forrester T, Wilks R: **Standardization of blood pressure measurement in an international comparative study.** *J Clin Epidemiol* 1996, **49**:869-877.
8. Burt VL, Whelton P, Roccella EL, Brown C, Cutler JA, Higgins M, Horan MJ, Labarthe D: **Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988-1991.** *Hypertension* 1995, **25**:305-313.

9. Joffres MR, Ghadirian P, Fodor JG, Petrasovits A, Chockalingam A, Hamet P: **Awareness, treatment, and control of hypertension in Canada.** *Am J Hypertens* 1997, **10**:1097-1102.
10. Primatesta P, Brooks M, Poulter NR: **Improved hypertension management and control: results from the Health Survey for England 1998.** *Hypertension* 2001, **38**:827-832.
11. Kastarinen MJ, Salomaa VV, Vartiainen EA, Jousilahti PJ, Tuomilehto JO, Puska PM, Nissinen AM: **Trends in blood pressure levels and control of hypertension in Finland from 1982 to 1997.** *J Hypertens* 1998, **16**:1379-1387.
12. Thamm M: **Blood pressure in Germany--current status and trends.** *Gesundheitswesen* 1999, **61**:90-93.
13. Giampaoli S, Palmieri L, Dima F, Pilotto L, Vescio MF, Vanuzzo D: **Socioeconomic aspects and cardiovascular risk factors: experience at the Cardiovascular Epidemiologic Observatory.** *It Heart J* 2001, **2**:294-302.
14. Banegas JR, Rodriguez-Artalejo F, de la Cruz Troca JJ, Guallar-Castillon P, del Rey Calero J: **Blood pressure in Spain: distribution, awareness, control, and benefits of a reduction in average pressure.** *Hypertension* 1998, **32**:998-1002.
15. Stegmayr B, Harmsen P, Rajakangas A, Rastenyte D, Sarti C, Thorvaldsen P: **Stroke around the Baltic Sea: Incidence, case fatality and population risk factors in Denmark, Finland, Sweden and Lithuania.** *Cerebrovasc Dis* 1996, **6**:80-88.
16. Wolf-Maier K, Cooper RS, Banegas JR, Biampaoli S, Hense H, Joffres M, Kastarinen M, Poulter N, Primatesta P, Rodriguez-Artalejo F, Stegmayr B,

- Thamm M, Tuomilehto J, Vanuzzo D, Vescio F: **Hypertension and blood pressure level in six European countries, Canada and the US.** *JAMA* 2003, **289**:2363-2369.
17. **The WHO MONICA Project. Geographical variation in the major risk factors of coronary heart disease in men and women aged 35-64 years.** *World Health Stat Q* 1988, **41**:115-140.
 18. Wolf HK, Tuomilehto J, Kuulasmaa K, Domarkiene S, Cepaitis Z, Molarius A, Sans S, Dobson A, Keil U, Rywik S: **Blood pressure levels in the 41 populations of the WHO MONICA Project.** *J Human Hypertens* 1997, **11**:733-742.
 19. Burt VL, Cutler JA, Higgins M, Horan MJ, Labarthe D, Whelton P, Brown C, Roccella EJ: **Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population. Data from the health examination surveys, 1960 to 1991.** *Hypertension* 1995, **26**:60-69.
 20. Hajjar I, Kotchen T: **Regional variations of blood pressure in the United States are associated with regional variations in dietary intakes: The NHANES-III data.** *Nutr* 2003, **133**:211-214.
 21. Freeman V, Rotimi C, Cooper R: **Hypertension prevalence, awareness, treatment, and control among African Americans in the 1990s: Estimates from the Maywood Cardiovascular Survey.** *Prev Med* 1996, **12**:177-185.
 22. Victor RG, Haley RW, Willett DL, Peshock RM, Vaeth PC, Leonard D, Basit M, Cooper RS, Iannacchione VG, Visscher WA, Staab JM, Hobbs HH; Dallas Heart Study Investigators: **The Dallas Heart Study: a population-based probability**

- sample for the multidisciplinary study of ethnic differences in cardiovascular health.** *Am J Cardiol* 2004, **93**:1473-1480.
23. Primates P, Bost L, Poulter NR: **Blood pressure levels and hypertension status among ethnic groups in England.** *J Hum Hypertens* 2000, **14**:143-148.
24. Cruickshank JK, Jackson SH, Bannan LT, Beevers DG, Beevers M, Osbourne VL: **Blood pressure in black, white and Asian factory workers in Birmingham.** *Postgrad Med J* 1983, **59**:622-626.
25. Lane D, Beevers, DG, Lip GYH: **Ethnic differences in blood pressure and prevalence of hypertension in England.** *J Hum Hypertens* 2002, **16**:267-273.
26. Cappuccio FP, Cooj DG, Atkinson RW, Wicks PD: **The Wandsworth Heart and Stroke Study. A Population –based study of cardiovascular risk factors in different ethnic groups. Methods and baseline findings.** *Nutr Metab Cardiovasc Dis* 1998, **8**:371-385.
27. Chaturvedi N, McKeigue PM, Marmot MG: **Resting and ambulatory blood pressure differences in Afro-Caribbeans and Europeans.** *Hypertension* 1993, **22**:90-96.
28. Agyemang C, Bhopal R. **Is the blood pressure of people from African origin adults in the UK higher or lower than that in European origin white people?** *J Human Hypertens* 2003, **17**:523-534.
29. Ordunez-Garcia P, Espinosa-Brito AD, Cooper RS, Kaufman J, Nieto FJ: **Hypertension in Cuba: Evidence of a narrow black-white difference.** *J Human Hypertens* 1998, **12**:111-116.

30. Miller GJ, Maude GH, Beckles GL: **Incidence of hypertension and non-insulin dependent diabetes mellitus and associated risk factors in a rapidly developing Caribbean community: the St James survey, Trinidad.** *J Epidemiol Community Health* 1996, **50**:497-504.
31. James SA, de Almeida-Filho N, Kaufman JS : **Hypertension in Brazil: a review of the epidemiological evidence.** *Ethn Dis* 1991, **1**:91-98.
32. Rywik SL, Davis CE, Pajak A, Broda G, Folsom AR, Kawalec E, Williams OD: **Poland and U.S. Collaborative Study on Cardiovascular Epidemiology. Hypertension in the community: Prevalence, awareness, treatment, and control of hypertension in the Pol-MONICA Project and the U.S. Atherosclerosis Risk in Communities study.** *Ann Epidemiol* 1998, **8**:3-13.
33. Strasser T: **Hypertension: The East European experience.** *Am J Hypertens* 1998, **11**:756-758.
34. Tyroler HA, Gasunov IS, Deev AD: **A comparison of high blood pressure prevalence and treatment status in selected US and USSR populations. First Joint US-USSR Symposium on Hypertension.** Bethesda, Md: NIH DHEW publication 79-1272, Bethesda, MD, 1979.
35. Kaufman J, Cooper RS: **Seeking causal explanations in social epidemiology.** *Am J Epidemiol* 1999, **150**:113-120.
36. Cooper RS, Kaufman JS: **Race and hypertension: Science or nescience?** *Hypertension* 1998, **32**:813-816.

37. Kaufman JS, Cooper RS, McGee D: **Socioeconomic status and health in blacks and whites: The problem of residual confounding and the resiliency of race.** *Epidemiology* 1997, **6**:621-628.
38. Cooper RS, Kaufman J, Ward R: **Race and genomics.** *N Engl J Med* 2003, **348**:1166-1170.

Figure Legends

Figure 1: Mean Systolic Blood Pressure, African Descent Populations; By Age Group

Figure 2: Mean Systolic Blood Pressure, European Descent Populations; By Age Group

Figure 3: Mean Systolic Blood Pressure, African and European Descent Populations; By Age Group

Figure 4: Hypertension Prevalence (140/90 mmHg or Treatment), African and European Descent Populations; Ages 35-64, Age Adjusted

Table 1
Mean Systolic and Diastolic Blood Pressure and Body Mass Index among
Persons 35-74 Years, in African- and European-Origin Populations *

	Total Sys / Dias (mmHg)	Men Sys / Dias (mmHg)	Women Sys / Dias (mmHg)	BMI, All (kg/m ²)
African-Origin Populations				
Nigeria	121.5/72.4	122.2/73.0	121.0/71.9	22.9
Jamaica	122.9/71.7	122.5/72.0	123.2/71.5	27.0
US - Black	129.7/78.5	130.3/80.8	129.1/76.3	28.5
European-Origin Populations				
US - White	120.9/75.2	123.4/78.2	118.3/72.2	27.3
Canada	128.2/80.8	131.2/83.2	125.1/78.5	26.8
Italy	129.8/83.1	132.4/85.4	127.2/80.7	26.4
Sweden	130.6/80.9	133.0/83.4	128.3/78.4	26.5
England	135.0/77.2	137.3/80.3	132.7/74.2	27.1
Spain	131.4/83.2	132.3/83.9	130.5/82.5	27.4
Finland	134.3/83.8	136.9/86.0	131.6/81.5	27.1
Germany	138.0/86.4	139.5/88.5	137.3/84.3	27.3

* Age-adjusted

Table 2
Hypertension Prevalence (%) among
Persons 35-64 Years, in African- and European-Origin Populations *

	Total (%)	Men (%)	Women (%)
African-Origin Populations			
Nigeria	13.5	13.9	13.1
Jamaica	28.6	23.4	31.8
US - Black	44.0	43.1	44.8
European-Origin Populations			
US - White	26.8	29.7	23.9
Canada	27.4	31.0	23.8
Italy	41.5	48.0	35.1
Sweden	38.4	44.8	32.0
England	41.7	46.9	36.5
Spain	46.8	49.0	44.6
Finland	48.6	55.7	41.6
Germany	55.3	60.2	50.4

* Age-adjusted

Appendix Table
Characteristics of the Surveys

Country	Survey Yr(s)	Population	N	Participation Rate (%)	Age Range	Sampling Method*
Nigeria	1991-93	Local	2,574	NA	25-74	Multistage, address
Jamaica	1993-95	Local	2,635	65	25-74	Multistage, address
USA, NHANES: Blacks	1988-94	National	4,984	82	18-80+	Multistage, population registry
Canada	1986-92	National	23,129	77.5	18-74	Multistage, medical insurance registries
England	1998	National	13,586	87.5	16-80+	Multistage, post code address
Finland	1997	National	7,159	72	25-64	Population registry
Germany	1997-9	National	7,124	61.4	18-79	Population registry
Italy	1998	National	8,233	-	35-74	Multistage, population registry
Spain	1990	National	2,021	73	35-65	Multistage, national registry
Sweden	1999	Regional	1,823	72	25-74	Population registry
USA, NHANES: Whites	1988-94	National	7,030	82	18-80+	Multistage, population registry

* All stratified sampling methods

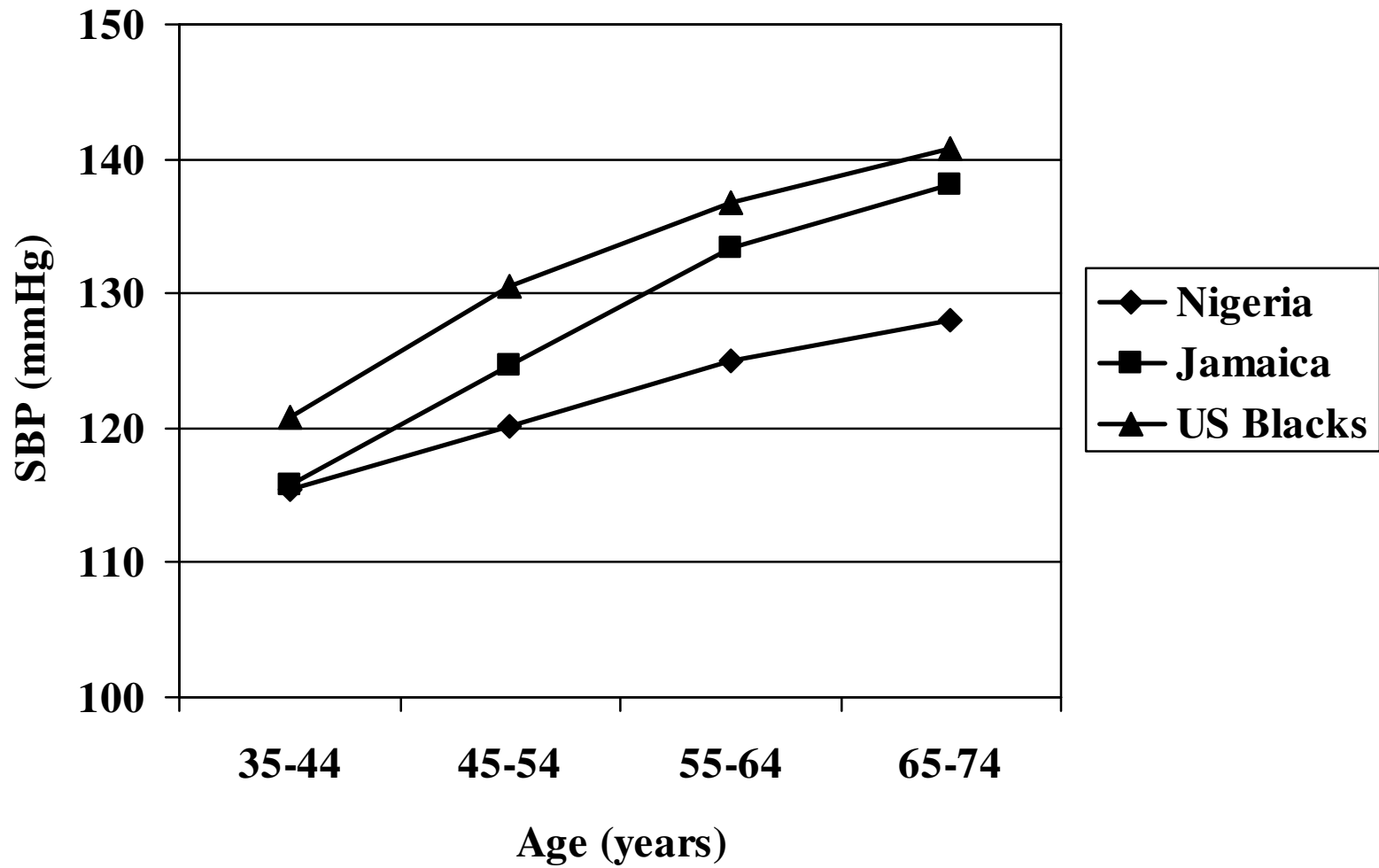


Figure 1

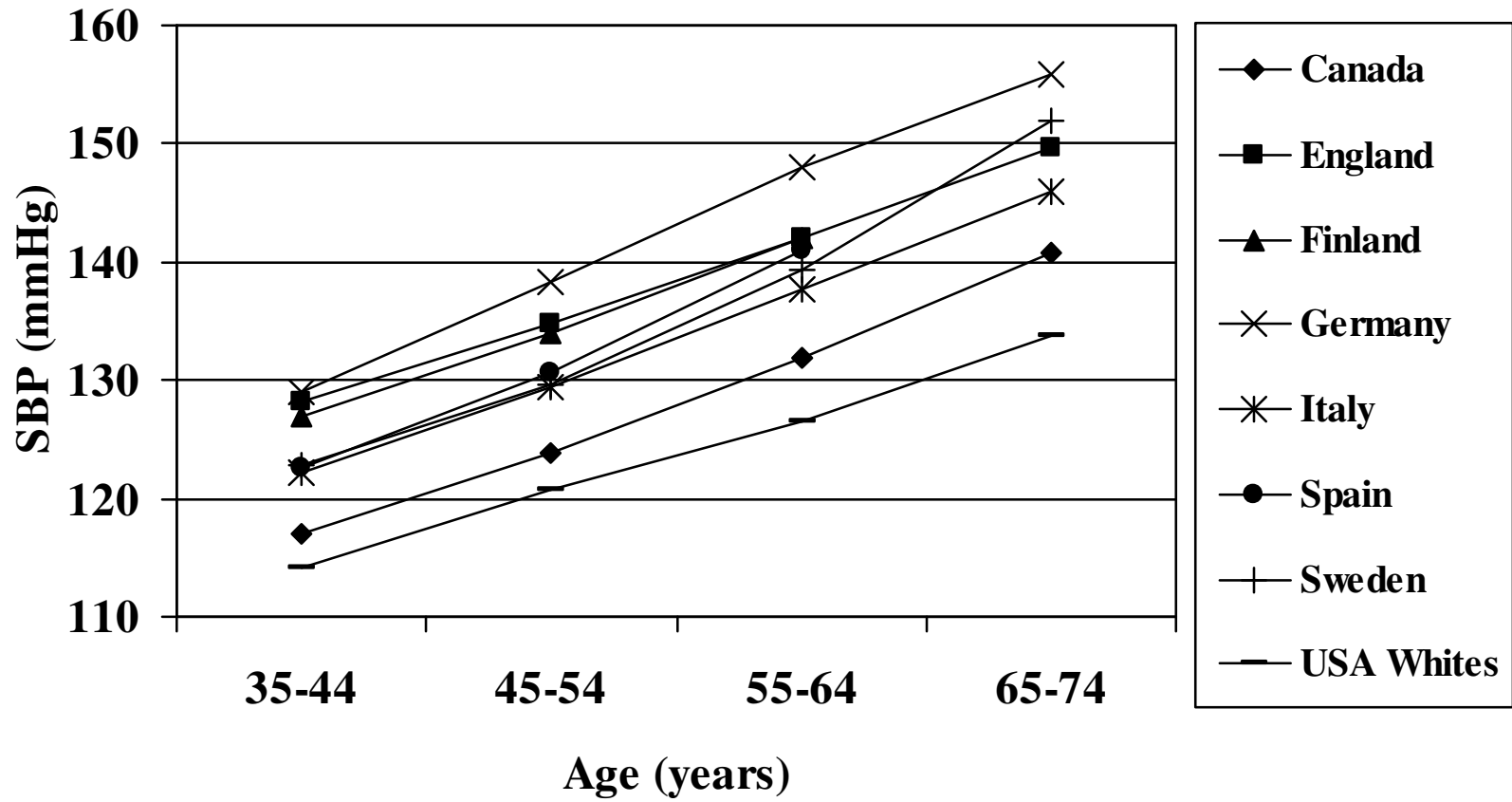


Figure 2

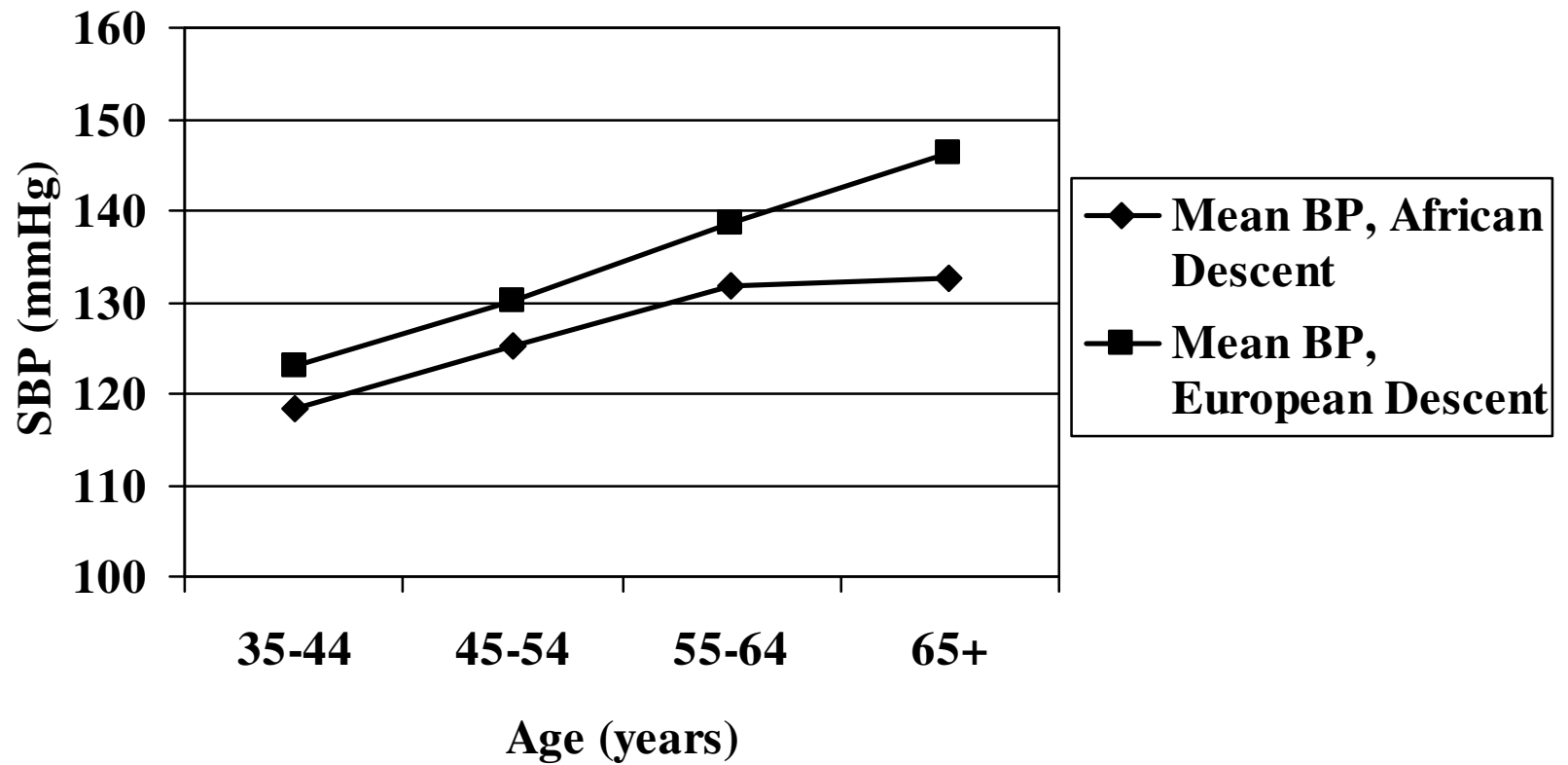


Figure 3

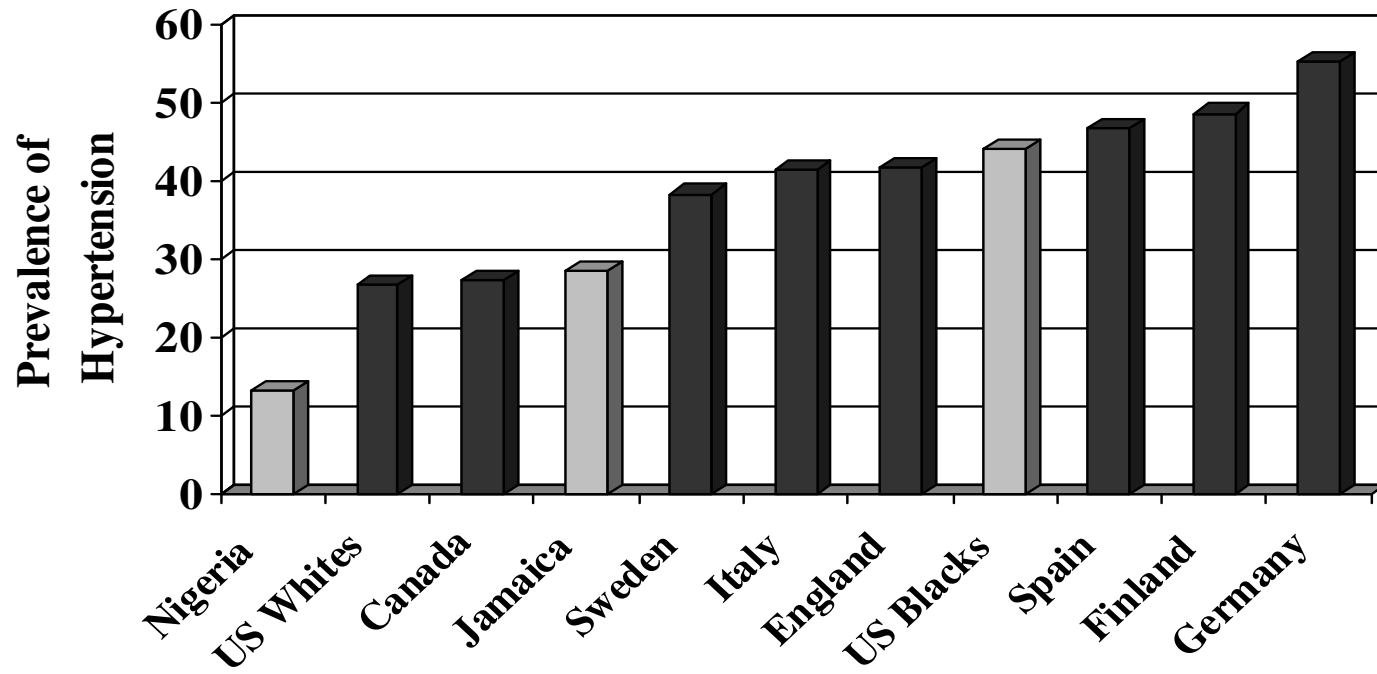


Figure 4