The Progression of Prehypertension to Hypertension Among Beneficiaries of the Military Health System

Vincent F. Carr, DO, Hope Gilbert, PhD, Lanna Forrest, PhD, James Fraser, MPH, and Joseph Kelly, PhD

The category of mild blood pressure elevation dubbed "prehypertension" has been associated with increased cardiovascular risks and is assumed to be a precursor to full-blown hypertension. These DoD researchers present an analysis of the condition's prevalence and progression in a large, military cohort.

In May 2003, the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) added a previously undefined category of high blood pressure designated "prehypertension." The report defined prehypertension as a systolic blood pressure between 120 and 139 mm Hg, a diastolic blood pressure between 80 and 89 mm Hg, or both.[1]

The prevalence of prehypertension has been examined in various populations.[2–14] In the general U.S. population, it is estimated at about 31% of adults—or 70 million people.[15] Although the health ramifications of prehypertension have not been explored fully, its significance in terms of cardiovascular risks and development of atherosclerosis has been well documented[3,8,15–25]—despite one study to the contrary.[26]

It is assumed that prehypertension is a precursor to hypertension.[15,22–24,27] This article gives some preliminary insight into how often prehypertension progresses to hypertension. In it, we present findings from a project conducted by the National Quality Management Program (NQMP), which involved a review of outpatient records of Military Health System (MHS) beneficiaries who were treated at 141 military treatment facilities (MTFs).[28,29] The primary objective was to determine the incidence of prehypertension progressing to hypertension, as defined by JNC 7. Additionally, the review examined various factors to determine whether they influenced the rate of progression from prehypertension to hypertension.

METHODS

For this retrospective, observational, quality assurance project, the NQMP reviewed a random outpatient medical record abstraction of 9,006 adult MHS beneficiaries covering the calendar year 2004.[28] Children and adolescent dependents of beneficiaries were excluded from the abstraction due to insufficient evidence regarding routine screening for pediatric hypertension prior to this project.[28–30] In addition, basic trainees and advanced individual trainees were not included as they were not enrolled as MHS beneficiaries. The project was deemed to be exempt from Institutional Review Board review by the congressional mandate establishing the NQMP.

Data on blood pressure measurements, weight, height, counseling (including diet, weight reduction, exercise, alcohol/substance abuse, smoking cessation, and self-monitoring of blood pressure counseling), and diagnoses were collected from the medical records. Additional data regarding counseling, medications, appointment utilization, and diagnostic codes for hypertension and for comorbid conditions were obtained from the MHS Data Repository (MDR), the Pharmacy Data Transaction Service (PDTS), Standard Inpatient Data Record (SIDR), Standard Ambulatory Data Report (SADR), Institutional Health Care Service Record (HCSRI-I), and Non-Institutional Health Care Service Record (HCSR-NI) files. Weight and height measurements documented in the medical records were used to calculate the body mass index (BMI) of beneficiaries included in the study.

Records containing documentation of a diagnosis of hypertension or an *International Classification of Diseases, Ninth Edition, Clinical Modification*

Dr. Carr is an assistant professor of medicine at Uniformed Services University of the Health Sciences, Bethesda, MD. **Dr. Gilbert** is a senior epidemiologist, **Dr. Forrest** is a program manager for the Center for Applied Research and Education, **Mr. Fraser** is a senior epidemiologists and **Dr. Kelly** is a project manager, all with Lockheed Martin, Falls Church, VA.

(ICD-9-CM) code for hypertension (401.0, 401.1, or 401.9) predating the beginning of the data collection period on January 1, 2004 were excluded from the analysis. The final patient sample consisted of 7,054 beneficiaries.

RESULTS

Of this cohort of 7,054 beneficiaries, about half (3,536, or 50.13%) met the JNC 7 criteria for prehypertension. Within this subcohort of prehypertensive beneficiaries, 38.32% were 35 years of age or older, 56.19% were serving on active duty, and 59.9% were male (Table 1).

Table 1 Demographic characteristics of study population

Characteristic	Normotensive, no. (%) (n = 3,518)	Prehypertensive, no. (%) (n = 3,536)	Overall sample, no. (%) (N = 7,054)
Age			
17–24 years	1,072 (30.47)	1,084 (30.66)	2,156 (30.56)
25–34 years	1,059 (30.10)	1,097 (31.02)	2,156 (30.56)
35–44 years	822 (23.37)	781 (22.09)	1,603 (22.72)
45–64 years	499 (14.18)	516 (14.59)	1,015 (14.39)
65 + years	66 (1.88)	58 (1.64)	124 (1.76)
Duty status			
Active duty	1,680 (47.75)	1,987 (56.19)	3,667 (51.98)
Non–active duty	1,838 (52.25)	1,549 (43.81)	3,387 (48.02)
Gender			
Male	1,595 (45.34)	2,118 (59.90)	3,713 (52.64)
Female	1,922 (54.63)	1,418 (40.10)	3,340 (47.35)
Missing/ unknown	1 (0.03)	0 (0.00)	1 (0.01)

Progression to hypertension

By the end of calendar year 2004, 209 (2.96%) of the total 7,054 beneficiaries had been newly diagnosed with hypertension. Among the prehypertensive cohort of 3,536 patients, 82 (2.45%) received new hypertension diagnoses.

Counseling for prehypertensive beneficiaries

Of the 3,536 prehypertensive beneficiaries included in the study, 3,348 had an MDR record 12 months following the initial prehypertension assessment and, thus, had the means for identifying counseling (188 prehypertensive beneficiaries did not have such records available). Among this group, the most common types of counseling received were diet (1,115 beneficiaries, or 33%) and exercise (1,045 beneficiaries, or 31%) counseling (Table 2). The incidence of progression to hypertension among beneficiaries who received diet counseling was 2.87%, compared with 2.24% among those who did not receive such counseling. Similarly, the incidence of progression to hypertension was 3.16% among beneficiaries who received exercise counseling, compared with 2.13% among those who did not receive exercise counseling. Overall, the lowest incidence of progression to hypertension (0%) occurred among the 21 beneficiaries who received counseling on self-monitoring of blood pressure, and the highest incidence (6.52%) occurred among the 138 beneficiaries who received counseling on weight reduction.

Concurrent comorbid conditions

Among those beneficiaries who were newly diagnosed with hypertension during the study period, multiple concurrent comorbid conditions were identified—based on ICD-9-CM and *International Classification of Diseases, 10th Edition* (ICD-10) codes abstracted from the medical records. (Comorbid conditions were considered "concurrent" if they occurred within the 12-month follow-up period used to detect progression to hypertension.) Of these conditions, the most frequent code identified was the ICD-10 code for "factors influencing health status and contact with health services" (used to capture nonspecific office visits), which was documented in the records of 80.86% of the newly hypertensive beneficiaries, followed by the ICD-9-CM code for "symptoms, signs, and ill-defined conditions," which was documented in the records of 70.81% of these beneficiaries. Other comorbid codes identified were for: "endocrine, nutritional and metabolic diseases, and immunity disorders" (48.33%), "diseases of the musculoskeletal system and connective tissue" (47.85%), "diseases of the respiratory system" (39.23%), "diseases of the nervous system" (39.23%), and "diseases of the circulatory system" (19.14%).

BMI

BMI calculations were classified into the standard three categories described in the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult

Table 2 Select counseling and patient education for prehypertensive beneficiaries

Type of counseling or education	Total, no. (%)[a] (N = 3,348)	Subsequent hypertension, no. (%)[b]	
		Yes (n = 82)	No (n = 3,266)
Diet			
No	2,233 (66.70)	50 (2.24)	2,183 (97.76)
Yes	1,115 (33.30)	32 (2.87)	1,083 (97.13)
Weight reduction			
No	3,210 (95.88)	73 (2.27)	3,137 (97.73)
Yes	138 (4.12)	9 (6.52)	129 (93.48)
Exercise			
No	2,303 (68.79)	49 (2.13)	2,254 (97.87)
Yes	1,045 (31.21)	33 (3.16)	1,012 (96.84)
Alcohol/substance abuse			
No	3,087 (92.20)	78 (2.53)	3,009 (97.47)
Yes	261 (7.80)	4 (1.53)	257 (98.47)
Smoking cessation			
No	2,818 (84.17)	75 (2.66)	2,743 (97.34)
Yes	530 (15.83)	7 (1.32)	523 (98.68)
Self-monitoring of blood pressure			
No	3,327 (99.37)	82 (2.46)	3,245 (97.54)
Yes	21 (0.63)	0 (0.00)	21 (100.00)
Patient refused any of the above counseling			
No	3,322 (99.22)	81 (2.44)	3,241 (97.56)
Yes	26 (0.78)	1 (3.85)	25 (96.15)
None of the above (other education or counseling)			
No	1,719 (51.34)	45 (2.62)	1,674 (97.38)
Yes	1,629 (48.66)	37 (2.27)	1,592 (97.73)

[a]Percentages in this column are based on the total of 3,348 prehypertensive beneficiaries who had a Military Health System Data Repository (MDR) record available 12 months following the initial prehypertension assessment and, thus, had the means for identifying counseling. The remaining 188 prehypertensive beneficiaries did not have such records available. [b]Percentages in these columns are based on the total number of prehypertensive beneficiaries (with a 12-month MDR record) who did or did not receive the specific type of counseling.

Treatment Panel III)[31]: normal/underweight (BMI of less than 25), overweight (BMI between 25 and 29.9), and obese (BMI of 30 or greater). Based on a χ^2 statistic, there was no significant difference (P = .38) with regard to BMI classifications between prehypertensive beneficiaries who developed hypertension and normotensive beneficiaries who developed hypertension. Overall, prehypertensive beneficiaries made up a smaller proportion of the normal BMI group (38.46%) than the normotensive beneficiaries (61.54%). Within strata, the proportion of obese beneficiaries among the subcohort of prehypertensive patients with subsequent hypertension was lower than that among the subcohort of normotensive patients with subsequent hypertension (28.77% versus 38.21%, respectively) (Table 3). In addition, the proportion of beneficiaries with a normal BMI among the prehypertensive cohort with subsequent hypertension was slightly higher than that among the normotensive subcohort with subsequent hypertension (20.55% versus 19.51%, respectively).

Continued on page 23

Continued from page 17

Table 3 Body mass index (BMI) classifications of beneficiaries who were newly diagnosed with hypertension during the study period

BMI classification	Total, no. (%) (N = 196)[a]	Initial blood pressure status, no. (%)	
		Prehypertensive (n = 73)[a]	Normotensive (n = 123)[a]
Normal (< 25.0)	39 (19.90)	15 (20.55)	24 (19.51)
Overweight (25.0–29.9)	89 (45.41)	37 (50.68)	52 (42.28)
Obese (≥ 30.0)	68 (34.69)	21 (28.77)	47 (38.21)

[a]A total of 13 beneficiaries who were newly diagnosed with hypertension during the study period did not have data available with which to calculate BMI—nine in the prehypertensive cohort and four in the normotensive cohort.

DISCUSSION

In the cohort of adult MHS beneficiaries, the proportions classified as normotensive, prehypertensive, and hypertensive are consistent with reports found in other published literature.[2,4–6,8]

As with all retrospective reviews, this analysis was subject to limitations related to lack of adequate data in the outpatient records. Unavailability of records was particularly problematic for certain Navy operational active duty personnel, as well as other deployed and afloat personnel, thus leading to potential bias in the evaluation of the prevalence of diagnoses among active duty members.

Numerous previous studies have documented an association between overweight and obesity and the development of hypertension. For instance, in a 2005 publication, Xu and Ragain cited data from the 1999–2000 National Health and Nutrition Examination Survey that showed 33% of hypertensive adults in the United States were overweight and 37% were obese.[6] In considering whether weight gain to the overweight or obese categories was associated with progression to hypertension, however, our study did not show a significant change of weight among beneficiaries who progressed to hypertension over the 12-month study period. In fact, among the beneficiaries who eventually progressed to hypertension, 45% and 35% already were classified as overweight and obese, respectively, at the outset of the study. As such, we could not make any association between weight gain and progression to hypertension based on our data. It's important to note that the classification of beneficiaries according to BMI does not consider lean body mass and, as such, may have resulted in inappropriate classification of some individuals with high lean body mass (such as body builders) into the overweight or obese categories. Nevertheless, this possible bias does not address this issue adequately and further study is needed.

In addition, the influence of diet,[6,12,32–36] exercise,[6,20,35,37–40] and weight reduction[6,35] counseling was not as successful in this study—in which such counseling did not appear to make any difference in avoiding the progression to hypertension—as has been previously described in medical literature. This discrepancy may reflect the use of more intense, individualized counseling sessions in the previous studies compared with our study, or it may reflect a lack of standardized protocols for counseling between the MHS beneficiary and MTF physician. As our study was a review of medical records without a specific counseling protocol, it is impossible to describe how intense the counseling sessions were or identify who provided the counseling (that is, a physician, nurse, dietician, or other health care professional). Consequently, no additional conclusions can be drawn and further study of specific counseling strategies is needed to determine their preventive value.

CONCLUSION

In this study there appears to be a small, but considerable, progression from prehypertension to stage 1 or 2 hypertension over the course of 12 months among adult military beneficiaries. Consistent patient follow-up, along with early identification and treatment based upon the JNC 7 guidelines, may increase awareness of the long-term health dangers of hypertension and lead to improved blood pressure control.

Acknowledgements

This study was funded by the DoD. The work was performed by Lockheed Martin for the DoD/Scientific Advisory Panel.

Author disclosures

The authors report no actual or potential conflicts of interest with regard to this article.

Continued on next page

Continued from previous page

Disclaimer

The opinions expressed herein are those of the authors and do not necessarily reflect those of Federal Practitioner, *Quadrant HealthCom Inc., the U.S. government, or any of its agencies. This article may discuss unlabeled or investigational use of certain drugs. Please review complete prescribing information for specific drugs or drug combinations—including indications, contraindications, warnings, and adverse effects—before administering pharmacologic therapy to patients.*

REFERENCES

1. Chobanian AV, Bakris GL, Black HR, et al; National Heart, Lung, and Blood Institute Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; National High Blood Pressure Education Program Coordinating Committee. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: The JNC 7 report [published correction appears in *JAMA.* 2003;290(2):197]. *JAMA.* 2003;289(19):2560–2572.
2. Okosun IS, Boltri JM, Anochie LK, Chandra KM. Racial/ethnic differences in prehypertension in American adults: Population and relative attributable risks of abdominal obesity. *J Hum Hypertens.* 2004;18(12):849–855.
3. Greenlund KJ, Croft JB, Mensah GA. Prevalence of heart disease and stroke risk factors in persons with prehypertension in the United States, 1999–2000. *Arch Intern Med.* 2004;164(19):2113–2118.
4. Russell LB, Valiyeva E, Carson JL. Effects of prehypertension on admissions and deaths: A simulation [published correction appears in *Arch Intern Med.* 2005;165(15):1720]. *Arch Intern Med.* 2004;164(19):2119–2124.
5. Wang Y, Wang QJ. The prevalence of prehypertension and hypertension among US adults according to the new joint national committee guidelines: New challenges of the old problem. *Arch Intern Med.* 2004;164(19):2126–2134.
6. Xu KT, Ragain RM. Effects of weight status on the recommendations of and adherence to lifestyle modifications among hypertensive adults. *J Hum Hypertens.* 2005;19(5):365–371.
7. Tsai PS, Ke TL, Huang CJ, et al. Prevalence and determinants of prehypertension status in the Taiwanese general population. *J Hypertens.* 2005;23(7):1355–1360.
8. Lloyd-Jones DM, Evans JC, Levy D. Hypertension in adults across the age spectrum: Current outcomes and control in the community. *JAMA.* 2005;294(4):466–472.
9. Qureshi AI, Suri MF, Kirmani JF, Divani AA. Prevalence and trends of prehypertension and hypertension in the United States: National Health and Nutrition Examination Surveys 1976 to 2000. *Med Sci Monit.* 2005;11(9):CR403–CR409.
10. Chockalingam A, Ganesan N, Venkatesan S, et al. Patterns and predictors of prehypertension among "healthy" urban adults in India. *Angiology.* 2005;56(5):557–563.
11. Ramos E, Barros H. Prevalence of hypertension in 13-year-old adolescents in Porto, Portugal. *Rev Port Cardiol.* 2005;24(9):1075–1087.
12. Grotto I, Grossman E, Huerta M, Sharabi Y. Prevalence of prehypertension and associated cardiovascular risk profiles among young Israeli adults. *Hypertension.* 2006;48(2):254–259.
13. Israeli E, Schochat T, Korzets Z, Tekes-Manova D, Bernheim J, Golan E. Prehypertension and obesity in adolescents: A population study. *Am J Hypertens.* 2006;19(7):708–712.
14. Choi KM, Park HS, Han JH, et al. Prevalence of prehypertension and hypertension in a Korean population: Korean National Health and Nutrition Survey 2001. *J Hypertens.* 2006;24(8):1515–1521.
15. Atilla K, Vasan RS. Prehypertension and risk of cardiovascular disease. *Expert Rev Cardiovasc Ther.* 2006;4(1):111–117.
16. Toikka JO, Laine H, Ahotupa M, et al. Increased arterial initima-media thickness and in vivo LDL oxidation in young men with borderline hypertension. *Hypertension.* 2000;36(6):929–933.
17. Washio M, Tokunaga S, Yoshimasu K, et al. Role of prehypertension in the development of coronary atherosclerosis in Japan. *J Epidemiol.* 2004;14(2):57–62.
18. Chrysohoou C, Pitsavos C, Panagiotakos DB, Skoumas J, Stefanadis C. Association between hypertension and inflammatory markers related to atherosclerotic disease: The ATTICA Study. *Am J Hypertens.* 2004;17(7):568–573.
19. King DE, Egan BM, Mainous AG III, Geesey ME. Elevation of C-reactive protein in people with prehypertension. *J Clin Hypertens (Greenwich).* 2004;6(10):562–568.
20. Fang J, Wylie-Rosett J, Alderman MH. Exercise and cardiovascular outcomes by hypertensive status: NHANES I epidemiological follow-up study, 1971–1992. *Am J Hypertens.* 2005;18(6):751–758.
21. Liszka HA, Mainous AG III, King DE, Everett CJ, Egan BM. Prehypertension and cardiovascular morbidity. *Ann Fam Med.* 2005;3(4):294–299.
22. Kshirsagar AV, Carpenter M, Bang H, Wyatt SB, Colindres RE. Blood pressure usually considered normal is associated with an elevated risk of cardiovascular disease. *Am J Med.* 2006;119(2):133–141.
23. Zhang Y, Lee ET, Devereux RB, et al. Prehypertension, diabetes, and cardiovascular disease risk in a population-based sample: The Strong Heart Study. *Hypertension.* 2006;47(3):410–414.
24. Greenberg J. Are blood pressure predictors of cardiovascular disease mortality different for prehypertensives than for hypertensives? *Am J Hypertens.* 2006;19(5):454–461.
25. King DE, Everett CJ, Mainous AG III, Liszka HA. Long-term prognostic value of resting heart rate in subjects with prehypertension. *Am J Hypertens.* 2006;19(8):796–800.
26. Bowman TS, Sesso HD, Glynn RJ, Gaziano JM. JNC 7 category and risk of cardiovascular death in men: Are there differences by age? *Am J Geriatr Cardiol.* 2005;14(3):123–131.
27. Julius S, Nesbitt SD, Egan BM, et al; for Trial of Preventing Hypertension (TROPHY) Study Investigators. Feasibility of treating prehypertension with an angiotensin-receptor blocker. *N Engl J Med.* 2006;354(16):1685–1697.
28. *The Association of Prehypertension with the Development of Hypertension*. Falls Church, VA: National Quality Management Program, TRICARE Management Activity, Dept of Defense; September 2005. https://www.mhs-cqm.info/Open/Education/CourseDetails.aspx?course_id=24. Accessed November 8, 2008.
29. *Blood Pressure Measurement and Management in the Military Health System*. Falls Church, VA: National Quality Management Program, TRICARE Management Activity, Dept of Defense; December 2004. https://www.mhs-cqm.info/Open/Education/CourseDetails.aspx?course_id=21. Accessed November 8, 2008.
30. Giles TD. Assessment of global risk: A foundation for a new, better definition of hypertension. *J Clin Hypertens (Greenwich).* 2006;8(8 suppl 2):5–14.
31. *Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III)—Final Report*. Bethesda, MD: National Cholesterol Education Program, National Heart, Lung, and Blood Institute, National Institutes of Health; September 2002. NIH publication no. 02-5215. http://www.nhlbi.nih.gov/guidelines/cholesterol/atp3full.pdf. Accessed November 8, 2008.
32. He J, Gu D, Wu X, et al. Effect of soybean protein on blood pressure: A randomized, controlled trial. *Ann Intern Med.* 2005;143(1):1–9.
33. Appel LJ, Sacks FM, Carey VJ, et al; for Omni-Heart Collaborative Research Group. Effects of protein, monounsaturated fat, and carbohydrate intake on blood pressure and serum lipids: Results of the OmniHeart randomized trial. *JAMA.* 2005;294(19):2455–2464.
34. Carey VJ, Bishop L, Charleston J, et al. Rationale and design of the Optimal Macro-Nutrient Intake Heart Trial to Prevent Heart Disease (OMNI-Heart). *Clin Trials.* 2005;2(6):529–537.
35. Elmer PJ, Obarzanek E, Vollmer WM, et al; PREMIER Collaborative Research Group. Effects of comprehensive lifestyle modification on diet, weight, physical fitness, and blood pressure control: 18-month results of a randomized trial. *Ann Intern Med.* 2006;144(7):485–495.
36. Wexler R, Aukerman G. Nonpharmacologic strategies for managing hypertension. *Am Fam Physician.* 2006;73(11):1953–1956.
37. Firdaus M. Prevention and treatment of the metabolic syndrome in the elderly. *J Okla State Med Assoc.* 2005;98(2):63–66.
38. Padilla J, Wallace JP, Park S. Accumulation of physical activity reduces blood pressure in the pre- and hypertension. *Med Sci Sports Exerc.* 2005;37(8):1264–1275.
39. Barlow CE, LaMonte MJ, Fitzgerald SJ, Kampert JB, Perrin JL, Blair SN. Cardiorespiratory fitness is an independent predictor of hypertension incidence among initially normotensive healthy women. *Am J Epidemiol.* 2006;163(2):142–150.
40. Kokkinos P, Pittaras A, Manolis A, et al. Exercise capacity and 24-h blood pressure in prehypertensive men and women. *Am J Hypertens.* 2006;19(3):251–258.