Five-Year Changes in Population Blood Pressure and Hypertension Prevalence

Results from the MONICA Augsburg Surveys 1984/85 and 1989/90

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ABSTRACT

Two cardiovascular risk factor surveys were carried out in 1984/85 and 1989/90 in the Augsburg study region of the international World Health Organization (WHO) Monitoring Trends and Determinants of Cardiovascular Disease (MONICA) project. Independent random samples of the 25- to 64-year-old population were examined at each survey. Five-year changes in blood pressure (BP) and hypertension parameters were monitored in a population not targeted by any formal intervention program. Response rates in both surveys ranged close to 80%. Evaluation of selected quality indicators confirmed comparability of the two surveys in terms of BP measurement quality. Small but consistent decreases in mean systolic and diastolic BP were observed, particularly for women 35 years and older, whereas BP changes in men were less pronounced and inconsistent. Likewise, downward shifts of the 10th, 50th, and 90th percentiles of systolic and diastolic BP occurred in women and their slopes of BP rise with age decreased while such changes were less clear in men. The age-standardized prevalence of men and women with hypertensive BP (HBP; ≥ 160/95 mm Hg) decreased slightly. This contrasted with rises in the prevalence of actual hypertension (those with HBP plus those taking antihypertensive drugs) for 45- to 64-year-old men, which originated from changes in hypertension management involving a more frequent drug treatment of borderline-hypertensive men (140 to 159/90 to 94 mm Hg) in 1989/90. There were notable overall increases in the awareness, treatment, and control of men and women with hypertension. In summary, based on a monitoring of the Augsburg population, prevention efforts in Germany between 1984/85 and 1989/90 appear to have been particularly successful for high-risk hypertensive individuals from both sexes. In the male population, no clear changes of BP distribution parameters could be detected while changes observed in women above 35 years old may be cautiously interpreted to indicate the onset of a downward shift of the entire BP distribution independent from antihypertensive medication use. Ann Epidemiol 1993;3:410–416.

KEY WORDS: Blood pressure, hypertension, population survey, time trends, prevention strategies.

INTRODUCTION

Arterial hypertension when undetected and untreated results in a twofold to fourfold increase in risk for cardiovascular morbidity and mortality (1). Elevated mean blood pressure (BP) values are, however, also a property of whole populations and generally originate from shifts of the entire BP distribution to higher values. Such conditions are observed in populations characterized as being at high risk of cardiovascular disease (2). Accordingly, preventive action in industrialized countries attempts to reduce the burden of cardiovascular disease by a high-risk strategy focusing on hypertensive individuals in the population and a mass strategy addressing the population as a whole (3, 4). The former consists primarily of hypertension screening and management programs and possesses essentially a curative, secondary prevention perspective, whereas the latter tries to prevent future BP elevations by propagating healthier life-styles and reducing epidemiologic BP determinants in the entire community. Indicators of successful high-risk strategies are declines in the prevalence of high BP, rises in the proportions of awareness and treatment of hypertension, and increased percentages of treated hypertensives whose BP is under adequate control. Likewise, an effective mass strategy is indicated by decreases in the population's mean, median, and percentile BP and by a reduction in the slope of BP rise with age.

In this report we present data from two cardiovascular risk factor surveys carried out in the MONICA study region of Augsburg (southern Germany) in 1984/85 and 1989/90.

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Five-year changes in population BP distribution parameters and in the prevalence of hypertension were monitored and assessed with reference to possible impacts of current high-risk and mass strategies of hypertension prevention in Germany. The MONICA Augsburg study population is not the target of a specific formal intervention program.

METHODS

The surveys were performed within the framework of the collaborative World Health Organization (WHO) MONICA project (5, 6). The study region for the MONICA Augsburg study comprises the city of Augsburg and two adjacent counties. The survey of 1984/85 was restricted to men and women 25 to 64 years old, and in 1989/90 to those 25 to 74 years old. Two independent samples were drawn from the respective age strata of the population in 1984 and in 1989, applying a two-stage cluster sampling method that was described in detail elsewhere (7). The 1984 sample consisted of 5312 subjects in eight and the 1989 sample of 6640 subjects in ten 10-year age-sex strata of 664 people each. There was practically no overlap in the subjects sampled for these two surveys.

Data were gathered through interview, physical examination, and self-administered questionnaire. Each survey lasted from October to May of the following year. A response of 80.0% of all eligible men (n = 2023) and 78.7% of eligible women (n = 1999) was obtained in 1984/85 (8). In 1989/90, of all eligibles in the age range of 25 to 64 years, 76.4% (n = 1962 men) and 77.2%, respectively (n = 2004 women), participated (9); individuals 65 years or older are not included in the present comparative analyses.

BP was measured with identical methods during both surveys. Three BP recordings were taken from each individual after completion of the interview, that is, after being at rest in a sitting position for an average of 30 minutes. A Hawksley random-zero sphygmomanometer was used. BP was measured under highly standardized conditions in accordance with the *MONICA Manual* (10), with 3-minute intervals between measurements. Different cuff sizes were available and used according to upper-arm circumference. Constant cuff deflation rates of 2 to 3 mm Hg/s and recording of results to the nearest even digit were enforced during training of BP observers. Korotkoff phase I sounds were used to record systolic and phase V sounds to record diastolic BP. The results given are based on the arithmetic mean of the second and third BP recordings.

Each participant was asked to bring to the interview all medications taken in the 7 days preceding examination. Drug brand names were obtained from the labels of these medications and the drugs were categorized using the Rote Liste, a German listing of drugs that is updated annually. Drugs were classified as "antihypertensive medication" when drug components were considered antihypertensively effective by the guidelines of the German League against Hypertension (11, 12). Participants reporting in the interview that they had been told before by a physician that they had high BP and who were taking such drugs were categorized as "treated hypertensives."

Methods were developed within the WHO MONICA project to assess BP measurement quality in different surveys. They involve the determination of last digit preference scores, proportions of identical results in multiple BP recordings (13), and calculations of coefficients of variation for individual measurements. For each survey, male and female participants were ordered in the sequence of their dates of examination and subsequently grouped into five classes of equal numerical size (i.e., in quintiles of examination date). Each group relates to one of five consecutive time periods which sum up to the entire survey duration. Deviations of the period-specific mean systolic and diastolic BPs from the overall survey mean were tested for statistical significance in order to detect time trends for BP results in surveys with expanded observation periods (14). The above methods were applied to assess potential differences in BP measurement quality between the 1984/85 and 1989/90 surveys.

We present age-specific and overall estimates of BP means and hypertension prevalence for each survey and report their differences with 90% confidence intervals (CI). Overall estimates were standardized to the age distribution of the West German population as of December 31, 1980. Slopes of systolic and diastolic BPs with age were obtained from regressions of BP on age for men and women separately and for each survey (15).

RESULTS

Last digit preference scores in both surveys were very low. For systolic BP measurements they reached 2.1 in 1984/85 compared to 4.4 in 1989/90 and for diastolic BP measurements, 8.1 and 8.4, respectively. The coefficients of variation for individual systolic BP measurements were 3.1% in 1984/85 and 4.5% in 1989/90 while for diastolic measurements they amounted to 4.1% and 6.0%. There were no differences in the proportions of identical duplicate measurements between 1984/85 and 1989/90 (17% and 21% for systolic and diastolic BP measurements, respectively). The time-trend analyses revealed no sizable or statistically significant deviations of the period specific from the overall BP means. The indicators of BP measurement quality were thus quite similar for the two surveys.

Small changes were observed in the population BP distribution parameters between 1984/85 and 1989/90 (Table 1). Decreases in mean systolic and diastolic BPs were mainly found above the age of 35 years. The decreases were larger

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TABLE 1. Mean systolic (SBP) and diastolic (DBP) blood pressures (mm Hg) in 1984/85 and in 1989/90 and between-survey differences with 90% confidence intervals, by age and sex: MONICA Project Augsburg, surveys 1984/85 and 1989/90

Age (y)	Survey 1984/1985			Survey 1989/1990			Differences 1984/1985 to 1989/1990	
	N_1	Mean SBP	Mean DBP	N_2	Mean SBP	Mean DBP	SBP	DBP
Men[a]	2023	132.5	82.7	1961	132.6	82.1	0.1 (−0.7, 0.9)	−0.6 (−1.2, 0.0)
24–34	464	128.1	78.2	469	128.7	78.3	0.6 (−0.7, 1.9)	0.1 (−1.0, 1.2)
35–44	485	130.5	84.1	462	130.7	83.3	0.2 (−1.3, 1.7)	−0.9 (−2.0, 0.3)
45–54	539	134.6	85.1	520	133.8	84.4	−0.8 (−2.6, 0.9)	−0.7 (−1.9, 0.4)
55–64	535	138.8	83.7	510	139.5	82.8	0.7 (−1.3, 2.7)	−0.9 (−2.1, 0.2)
Women[a]	1999	125.2	78.2	2004	124.4	77.1	−0.8 (−1.6, 0.0)	−1.1 (−1.6, −0.5)
25–34	463	115.1	72.4	476	116.1	72.5	1.0 (−0.2, 2.2)	0.1 (−0.9, 1.2)
35–44	523	121.0	77.5	486	120.1	76.0	−1.0 (−2.5, 0.5)	−1.5 (−2.6, −0.4)
45–54	515	130.7	82.4	539	129.1	80.5	−1.6 (−3.5, 0.3)	−1.9 (−3.1, −0.8)
55–64	498	138.7	81.9	503	136.6	80.9	−2.1 (−4.1, −0.1)	−1.0 (−2.1, 0.1)

[a] Age standardized to the population of West Germany as of December 31, 1980.

and more consistent in women than in men, particularly since in the latter, systolic BP means in most age groups exhibited a weak upward trend.

Figure 1 confirms that the changes in women originated from a fairly small but consistent downward shift of the entire systolic and diastolic BP distribution involving the 10th, 50th, and 90th percentile values. A similar shift was apparent for diastolic BP in men, which contrasted the observation that particularly for older men, the upper percentile values of systolic BP ranged clearly higher than 5 years earlier (e.g., the 90th percentiles at 45 to 54 years: 159 versus 156 mm Hg; at 55 to 64 years: 167 versus 164 mm Hg). The prevalence of antihypertensive medication use by Augsburg men rose considerably; for example, in men aged 55 to 64 years it increased from 13 to 23%. This increase was, however, not accompanied by distinct downward shifts of the upper parts of the BP distribution (see Figure 1). By contrast, although the prevalence of antihypertensive medication use did not substantially change over the five years in Augsburg women, their upper BP percentile values had decreased in 1989/90.

The slopes of BP rise with age changed in men and women in the same direction as BP means and percentiles (Table 2). The slopes remained essentially the same for systolic BP in men, fell slightly for diastolic BP in both sexes, and decreased significantly for systolic BP in women (difference: −1.2 mm Hg per 10 years; 90% CI: −0.5 to −1.9).

The age-standardized prevalence of hypertensive BP (HBP) (i.e., ≥ 160 mm Hg and/or ≥ 95 mm Hg) decreased slightly from 1984/85 to 1989/90 for both men and women (Table 3). While in women the 5-year differences in HBP prevalence became larger with each decade, no clear age relationship of HBP was apparent in men. Inclusion of all hypertensives with pharmaceutically lower BPs below 160/95 mm Hg (i.e., determination of the prevalence of actual hypertension (AHT)) resulted for men in rises of the age-standardized AHT prevalence from 1984/85 to 1989/90 (see Table 3). These rises were substantial in men 45 to 54 years old (+4.1% (−0.3 to 8.4)) and in those aged 55 to 64 years (+7.1% (2.3 to 11.9)). When, however, a low cutpoint definition for actual hypertension was applied (i.e., systolic ≥ 140 mm Hg and/or diastolic ≥ 90 mm Hg or taking antihypertensive medication), magnitude and direction of the AHT prevalence changes in men and women became quite similar to those described above for the BP means (Table 4). In men aged 45 to 64 years, marked AHT rises occurred exclusively at the 160/95 mm Hg cutpoint while AHT prevalences based on the 140/90 mm Hg cutpoint remained practically unchanged (+0.9% and +0.5%, respectively). By contrast, AHT declines of −2.7% and −3.5% were observed in women from these age groups when calculations were based on the low cutpoint definition.

Awareness, treatment, and control of hypertension rose especially in hypertensive men above 45 years old (see Table 4). Hypertensive women showed quantitatively less pronounced improvements in these indicators of hypertension management quality but their degree of awareness, treatment, and control in 1989/90 remained still distinctly higher than in men.

DISCUSSION

Our surveys were carried out in two independent, nonoverlapping samples of 25- to 64-year-old residents from the MONICA Augsburg region in order to monitor 5-year changes in risk factor levels of a defined age range of our study population. Thus, in the 1989/90 survey, we sampled birth cohorts that were 5 years older than the ones we had examined in 1984/85. Such an approach is conceptually different from a cohort follow-up and serves to monitor secular trends in a population rather than to investigate prospective changes in a group of individuals.

Earlier reports from the MONICA Augsburg study have shown high average body mass indexes and comparatively high daily intakes of alcohol, in particular of beer (9, 16,

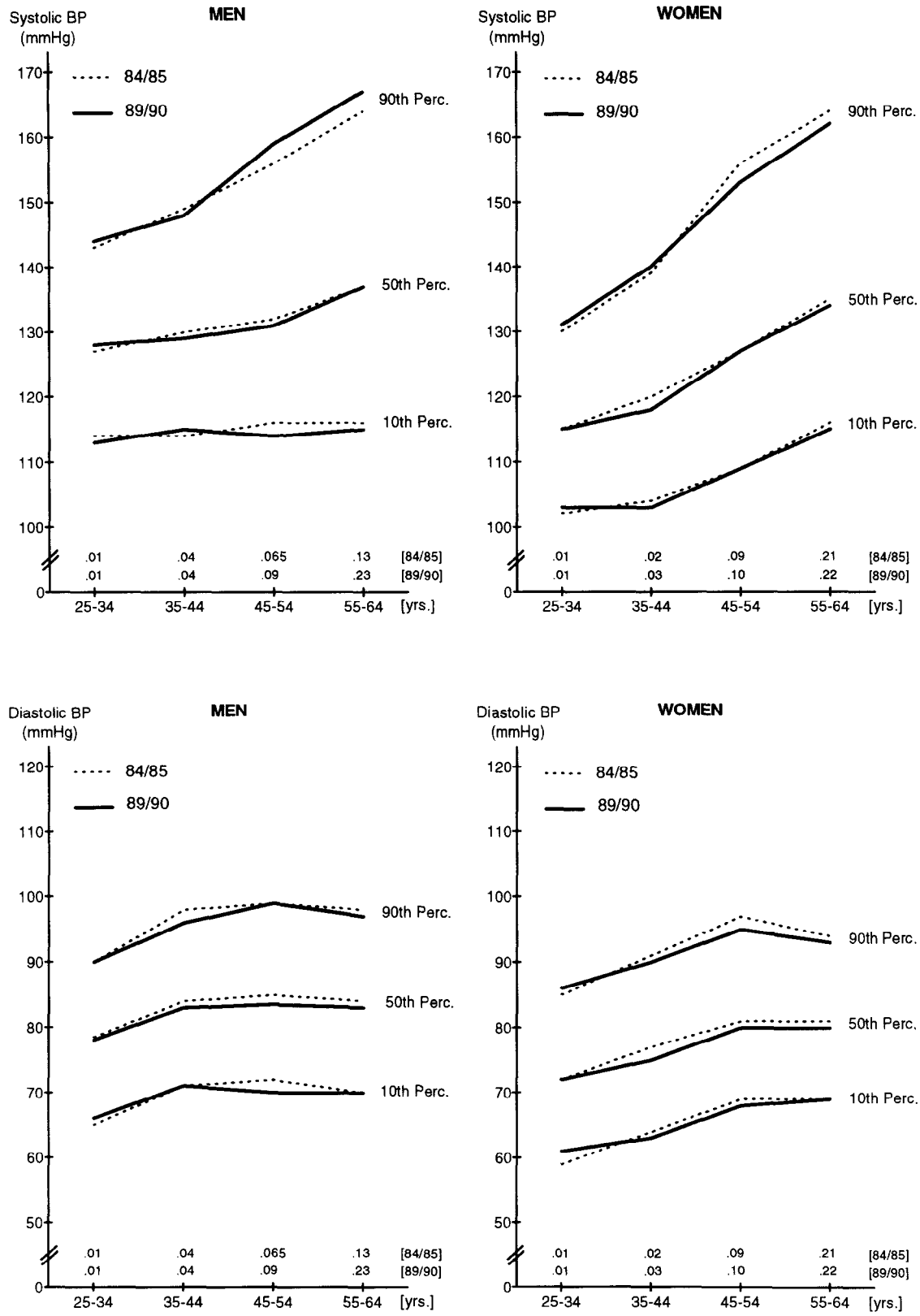

FIGURE 1. Age-specific 10th, 50th, and 90th percentiles of systolic and diastolic blood pressures (BP) in 1984/85 and 1989/90. Numbers at the bottom of each panel indicate the proportion of the population in each age group taking antihypertensive medication in 1984/85 and 1989/90. Men and women, 25 to 64 years old, MONICA Augsburg surveys 1984/85 and 1989/90.

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TABLE 2. Slopes of rise of systolic (SBP) and diastolic (DBP) blood pressure with age (90% confidence levels) obtained as regression coefficients from separate linear regressions of blood pressure on age: Men and women, 25 to 64 years old, MONICA Project Augsburg, surveys 1984/84 and 1989/90

	Rise of SBP with age (mm Hg/10 y)	Rise of DBP with age (mm Hg/10 y)
Men		
1984/85	3.6 (3.1, 4.1)	1.8 (1.4, 2.2)
1989/90	3.7 (3.1, 4.2)	1.4 (1.1, 1.8)
Women		
1984/85	8.2 (7.6, 8.7)	3.4 (3.0, 3.7)
1989/90	7.0 (6.5, 7.5)	2.9 (2.6, 3.3)

17). Comparisons of the two surveys confirmed that these levels remained high between 1984/85 and 1989/90 (16) and that the only significant changes occurred in smoking prevalences, with a drop of 3.9% (95% CI: 0.9 to 6.9) in men and an increase of 4.1% (1.5% to 6.6%) in women (9).

The present analyses indicate that the MONICA Augsburg surveys of 1984/85 and 1989/90 achieved comparably high levels of BP measurement quality. Both surveys applied identical procedures of training and certification of observers. Further, a quantitative assessment of indicators of BP measurement quality, developed specifically for this purpose (13, 14), supports this contention. These indicators assess the reliability and to a certain extent also the validity of BP measurements in independent epidemiologic surveys and are a valuable prerequisite for meaningful cross-sectional comparisons of BP means and hypertension prevalences in populations. Based on these assessments we assume that the 5-year BP changes reported here for the MONICA Augsburg study population were not subject to substantial bias by intersurvey differences in BP measurement quality. In addition, high participation rates close to 80% in each survey make it unlikely that differential participation may have introduced a selection bias.

Changes that occurred between 1984/85 and 1989/90 in the Augsburg study population were assessed in terms of comparisons of BP distribution parameters and in terms of differences in hypertension prevalence and management indicators. Given the short observation period of 5 years, these changes were expected to be quantitatively small, especially with regard to population BP distribution. And indeed, the age-specific and age-standardized overall differences in mean systolic and diastolic BPs of men never exceeded 1 mm Hg and the 90% CIs clearly overlapped the zero value. The absence of noteworthy differences in the 10th, 50th, and 90th BP percentiles as well as in the slopes of BP rises with age support the impression that no sizable trends occurred in the Augsburg males' BP distributions from 1984/85 to 1989/90. A tendency toward lower diastolic BP in men above 35 years old should, however, not be dismissed completely.

More consistent and larger decreases were observed in Augsburg women. The falls in age-standardized mean systolic BP by −0.8 mm Hg (−1.6 to 0.0) and in mean diastolic BP by −1.1 mm Hg (−1.6 to −0.5) were mainly attributable to marked decreases in women 35 years and older. Further evidence for a small but distinct population-wide downward shift of female BP distributions is provided by the downward trend in BP percentiles and reduced slopes of BP rise with age. Finally, the increased prevalence of women having BPs below 140/90 mm Hg without antihypertensive treatment (i.e., the complement of AHT at 140/90 mm Hg in Table 4) can only be explained by a downward shift of the BP distributions that is unrelated to frequency or intensity of antihypertensive medication.

The prevalence of AHT at 160/95 mm Hg in women remained largely unchanged over the study period. High levels of hypertension awareness were already present in

TABLE 3. Prevalences of hypertensive blood pressure (HBP) values (i.e., ≥ 160/95 mm Hg) and actual hypertension (AHT) (i.e., ≥ 160/95 mm Hg or taking antihypertensive medication) in 1984/85 and 1989/90, and between-survey differences with 90% confidence intervals (CI), by age and sex: MONICA Project Augsburg, surveys 1984/85 and 1989/90

	Survey 1984/1985			Survey 1989/1990			Differences 1984/1985 to 1989/1990	
Age (y)	N_1	HBP (%)	AHT (%)	N_2	HBP (%)	AHT (%)	HBP (%) (90% CI)	AHT (%) (90% CI)
Men[a]	2023	15.6	18.6	1961	14.7	20.2	−0.9 (−2.7, 0.9)	1.6 (−0.4, 3.6)
25–34	464	6.5	7.3	469	6.2	7.0	−0.3 (−2.9, 2.3)	−0.3 (−3.1, 2.5)
35–44	485	16.9	19.0	462	13.4	16.5	−3.5 (−7.3, 0.3)	−2.5 (−6.6, 1.6)
45–54	539	19.7	22.1	520	20.2	26.2	0.5 (−3.5, 4.6)	4.1 (−0.3, 8.4)
55–64	535	21.5	29.5	510	21.8	36.7	0.3 (−3.9, 4.5)	7.1 (−2.3, 11.9)
Women[a]	1999	9.2	13.7	2004	8.2	13.7	−1.0 (−2.4, 0.4)	0.0 (−1.6, 1.6)
25–34	463	1.1	1.5	476	1.5	2.1	0.4 (−0.8, 1.6)	0.6 (−0.8, 2.0)
35–44	523	6.1	7.6	486	6.0	8.0	−0.2 (−2.6, 2.3)	0.4 (−2.4, 3.2)
45–54	515	15.1	20.6	539	13.0	19.5	−2.2 (−5.7, 1.4)	−1.1 (−5.2, 3.0)
55–64	498	17.9	31.3	503	15.1	31.4	−2.8 (−6.6, 1.1)	0.1 (−4.7, 4.9)

[a] Age standardized to the population of West Germany as of December 31, 1980.

TABLE 4. Prevalence (%) of actual hypertension (defined at two different cutpoints) and proportions of actual hypertensives who were aware, treated, and controlled in 1984/85 and in 1989/90: Men and women, 45 to 54 and 55 to 64 years old, MONICA Project Augsburg surveys 1984/85 and 1989/90

	≥160/95 mm Hg		≥140/90 mm Hg	
	Survey 1984/85	Survey 1989/90	Survey 1984/85	Survey 1989/90
Men				
45–54 y				
Prevalence	22.1	26.2	44.9	45.8
Proportion				
Aware	58.8	69.1	41.7	51.3
Treated	29.4	34.6	14.5	19.7
Treated, controlled	10.9	22.8	4.1	8.0
55–64 y				
Prevalence	29.5	36.7	54.6	55.1
Proportion				
Aware	79.1	81.3	54.4	62.6
Treated	44.3	62.0	24.0	41.3
Treated, controlled	27.2	40.6	6.5	13.9
Women				
45–54 y				
Prevalence	20.6	19.5	34.2	31.5
Proportion				
Aware	81.1	81.0	65.9	65.3
Treated	44.3	53.3	26.7	32.9
Treated, controlled	26.4	33.3	6.3	11.8
55–64 y				
Prevalence	31.3	31.4	52.4	48.9
Proportion				
Aware	89.1	86.7	70.5	67.5
Treated	68.6	71.5	41.0	45.9
Treated, controlled	42.9	51.9	12.6	15.0

1984/85 and did not improve further. However, the proportions of women whose hypertension was treated and controlled were further raised, thus leading to moderate declines in the prevalence of HBP, especially above the age of 45 years. The increases in awareness, treatment, and control of hypertension were even more pronounced in men (see Figure 1, Table 4). This was paralleled by a substantial shift of antihypertensive medication use in hypertensive men toward novel drug types like angiotensin-converting enzyme (ACE) inhibitors and calcium channel blockers (16). These results are compatible with a successful maintenance of high levels of hypertension detection and an increased use and efficacy of current antihypertensive medications in the Augsburg population.

From this background, the seemingly paradoxical increase of the AHT prevalence at cutpoint 160/95 mm Hg in men aged 45 years and older must not be misinterpreted. It appears mostly due to a methodologic artifact. This becomes evident when comparing the AHT prevalences at two different cutpoints: Despite clear rises at cutpoint 160/95 mm Hg, the prevalences at cutpoint 140/90 mm Hg remained essentially unchanged from 1984/85 to 1989/90. Taking into account that in this age range the prevalence of men with HBP had not changed over the 5 years and that there were no indications of upward BP distribution shifts potentially giving rise to higher incidences and prevalences of hypertension, the only conceivable explanation for our findings remains in changes in the management of hypertension: Treating more males with initial BP between 140 and 159 mm Hg systolic and/or 90 to 94 mm Hg diastolic (i.e., with mild or borderline hypertension) adds numerous subjects to the AHT subgroup of "controlled" hypertensives, although based on the 160/95 mm Hg cutpoint, these subjects would not have required treatment in the first place. The result is an increase in AHT prevalence when using the 160/95 mm Hg cutpoint while at the same time not affecting prevalence estimates at the 140/90 mm Hg cutpoint. Intensified therapy of formerly unmedicated individuals with only mildly elevated BP is in accordance with recent recommendations (18, 19) and seems to be gradually accepted also by the German medical community (20). As illustrated here, alterations in disease management can falsely raise prevalence measures in epidemiologic surveys. Misinterpretations of such artificial rises can be avoided when different indicators of a population's BP status are reported and checked for consistency.

Results from an American cardiovascular disease surveillance program, the Minnesota Heart Survey of 1980/82 and 1985/87 (21), indicate 5-year changes that are similar to the ones observed in MONICA Augsburg, although the levels of average BP and hypertension prevalence are sizably higher in the Augsburg population. In the Minnesota Heart Survey, the changes in mean BP were also in the order of about 1 mm Hg and they were more pronounced in women. The prevalences of actual hypertension at cutpoint 140/90 mm Hg decreased nonsignificantly in both sexes but they were slightly more pronounced in females. This could indicate that despite a marked population variance in hypertension prevalence, secular trends showed a similar strength and the same direction in both populations.

We conclude that between 1984/85 and 1989/90, notable rises in the degree of awareness, treatment, and control of hypertension occurred in the MONICA Augsburg study region although no specific intervention program has been established. Community physicians appeared to initiate treatment, particularly in hypertensive men, at lower BP levels than they had done 5 years before. Independent of the intensified treatment of high-risk individuals, systolic and diastolic BP distribution parameters decreased moderately but consistently in women above 35 years old. This can be cautiously interpreted to indicate the onset of a population-wide BP reduction, possibly attributable to an intensified community health promotion in Germany in recent years.

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