

Long-Term and Recent Progress in Blood Pressure Levels Among U.S. Adults With Diagnosed Diabetes, 1988–2008

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OBJECTIVE—To examine whether there were long-term (between 1988–1994 and 2001–2008) and recent (between 2001–2004 and 2005–2008) changes in blood pressure (BP) levels among U.S. adults with diagnosed diabetes.

RESEARCH DESIGN AND METHODS—Using data from National Health and Nutrition Examination Surveys (NHANES), we examined changes in BP distributions, mean BPs, and proportion with BP <140/90 mmHg.

RESULTS—Between 1988–1994 and 2001–2008, for adults with diabetes, mean BPs decreased from 135/72 mmHg to 131/69 mmHg ($P < 0.01$) and the proportion with BP <140/90 mmHg increased from 64 to 69% ($P = 0.01$). Although hypertension prevalence increased, hypertension awareness, treatment, and control improved. However, there was no evidence of improvement for adults 20–44 years old. Between 2001–2004 and 2005–2008, there were no significant changes in BP levels.

CONCLUSIONS—BP levels among adults with diabetes improved between 1988–1994 and 2001–2008, but the progress stalled between 2001–2004 and 2005–2008. The lack of improvement among young adults is concerning.

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Hypertension is particularly deleterious for people with diabetes because it confers 2–3 times the risk for cardiovascular morbidity and mortality as for people without diabetes (1,2). Studies demonstrated that blood pressure (BP) control is crucial to reduce vascular complications and improve survival for people with diabetes (3,4). The proportion of people with diabetes with poorly controlled BP declined considerably between the 1970s and the 1990s (5). However, in recent studies using the National Health and Nutrition Examination Surveys (NHANES) data, no improvements in BP levels among adults with diabetes were observed from 1988–1994 to early

2000s (6) or from 1999 to 2006 (7). We updated prior studies with the most recent NHANES 2007–2008 data to examine long-term (between 1988–1994 and 2001–2008) and recent (between 2001–2004 and 2005–2008) changes in BP levels among U.S. adults with diagnosed diabetes.

RESEARCH DESIGN AND METHODS

We analyzed data from the NHANES 1988–1994 and 2001–2008. Our study included adults aged 20 years or older with self-reported diagnosed diabetes (regardless of hypertension status). We used an average of up to three BP readings to determine an

individual's BP level. After excluding people with missing BP values ($n = 192$), 3,255 people were included in final analysis.

Our outcome measures included BP distributions, mean systolic BP (SBP) and diastolic BP (DBP), and the proportion with SBP <140 and DBP <90 mmHg. To define categories for BP distributions, we adopted a method applied by Cheng et al. (8). Using combined NHANES 1988–1994 and 2001–2008 data, we first identified the 2.5 and 97.5 percentiles of the BP distribution of the study population; next, we equally divided the BP values between the 2.5 and 97.5 percentiles into nine intervals; we then conducted multiple categorical logistic regression to obtain the predicted percentage in each BP category for each study period adjusting for age, sex, and race/ethnicity.

Hypertension was defined as SBP ≥ 140 mmHg or DBP ≥ 90 mmHg, or self-reporting of taking antihypertensive medications. Among those with hypertension, participants were considered aware of hypertension status if they answered that they had been told that they had hypertension; those who reported taking antihypertensive medications were considered under treatment, and those with SBP <140 mmHg and DBP <90 mmHg were considered to have BP in control.

Data analyses were performed using SAS 9.1.3 and SUDAAN 9.0. Mean BPs, the proportion with BP <140/90 mmHg, and hypertension prevalence, awareness, treatment, and control rate were age-adjusted to the NHANES 2005–2008 diabetic population. We used t tests to assess differences in means and rates between time periods. A P value < 0.05 was considered statistically significant.

RESULTS—Figure 1 depicts shifts in both SBP and DBP distributions toward lower levels between 1988–1994 and 2001–2008. However, only a small percentage in either period had DBP ≥ 90 mmHg.

Between 1988–1994 and 2001–2008, overall mean BPs decreased from 135/72 mmHg to 131/69 mmHg (P value < 0.01).

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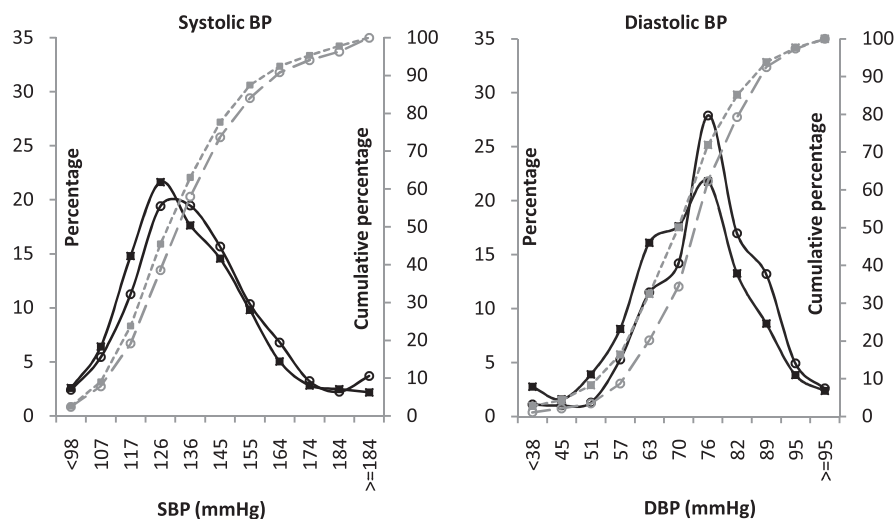
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solid line with circles=percentage for 1988-1994;
 solid line with squares=percentage for 2001-2008
 dotted line with circles=cumulative percentage for 1988-1994;
 dotted line with squares=cumulative percentage for 2001-2008
 * Adjusted for age, sex, and race/ethnicity.

Figure 1—Adjusted (*) BP distributions for U.S. adults with diabetes, 1988–1994 vs. 2001–2008.

Mean BPs decreased in all subgroups except for adults aged 20–44 years (Supplementary Table 1). The overall age-adjusted proportion with BP <140/90 mmHg increased from 63.8 to 69.2% ($P = 0.01$). The increase was significant for adults aged 45–64 years, women, non-Hispanic blacks, and Mexican Americans, but not for other subgroups.

Between 1988–1994 and 2001–2008, age-adjusted hypertension prevalence increased from 56.0 to 67.3% ($P < 0.01$) overall, but did not increase significantly among women, Mexican Americans, and adults aged 20–44 years (Supplementary Table 2). Overall, improvements were seen in age-adjusted hypertension awareness (84.1 to 92.3%), treatment (75.0 to 88.4%), and control (38.1 to 54.0%) (all $P < 0.01$). Adults aged 20–44 years experienced no significant increase in any of these measures, and Mexican Americans had no significant improvement in awareness of hypertension.

Between 2001–2004 and 2005–2008, there was no significant change for overall mean BP (SBP, 131.7 vs. 131.3 mmHg, $P = 0.7$; DBP, 68.3 vs. 68.9 mmHg, $P = 0.6$) and for the age-adjusted proportion with BP <140/90 mmHg (69.7 vs. 68.7%, $P = 0.7$) (Supplementary Table 3). Furthermore, no significant changes were found for any subgroups analyzed. There were also no significant

changes in hypertension prevalence, awareness, treatment, and control for all groups except for hypertension prevalence increasing for young adults ($P = 0.02$) (Supplementary Table 4).

CONCLUSIONS—BP levels among U.S. adults with diabetes improved between 1988–1994 and 2001–2008. There was no evidence of any improvement among adults aged 20–44 years. Virtually all of the improvements were limited to the 1990s, and no significant improvements were seen in the 2000s.

The improvement in BP levels, in conjunction with prior reported improvement in A1C levels (9), may indicate encouraging trends in diabetes management. Indeed, despite upward hypertension prevalence, which may be driven in part by rising obesity (10), BP levels improved, indicating probably more effective hypertension management. During our study period, landmark clinical trials showed that BP control reduced vascular complications (3,4) and new clinical guidelines lowered BP targets to <130/80 mmHg (11,12). Awareness of the benefits of BP control may have increased and treatment intensified. Furthermore, the lowered BP target might have resulted in earlier diagnosis and treatment at lower BP levels, contributing not only to the observed increase in hypertension prevalence but also to

increased awareness, treatment, and control rates.

The lack of improvement among young adults is concerning because of their future risk of developing vascular complications at younger ages. Several factors could explain the poor levels of control in younger patients, including a lower adherence to medications (13); a lower tendency to receive treatment intensification (14); and less optimal care for hypertension, i.e., delayed initiation of pharmacotherapy when lifestyle intervention fails (15).

Limitations of our study include the relative small sample sizes for young adults, which may limit our ability to detect small changes. BP measurement errors may also exist since BP was measured at a single occasion in the NHANES. However, the methods were consistent across all NHANES and BP levels were based on averaged readings.

Finally, we found that the progress in BP levels in the adult population with diabetes may have stalled in 2000s. Although hypertension awareness and treatment rates are now high (~90%), hypertension prevalence remains high and control rates are suboptimal, indicating need for effective prevention and control strategies.

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