

## Income Inequality and Hypertension Control

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**H**ealth disparities that exist between different socioeconomic status (SES) groups remain a consistent finding in epidemiologic research.<sup>1</sup> Seminal studies including the Whitehall studies conducted among British civil servants have shown that lower SES is associated with increased cardiovascular disease (CVD) risk.<sup>2,3</sup> Subsequent research has demonstrated that several measures of SES including income level, educational attainment, employment status, and environmental factors are associated with an increased risk of CVD.<sup>1</sup>

Several factors contribute to the development of CVD, and hypertension is among the most important.<sup>4</sup> Hypertension is associated with an increased risk of coronary heart disease, stroke, heart failure, peripheral arterial disease, and all-cause mortality, as well as target end-organ damage including left ventricular hypertrophy and chronic kidney disease.<sup>5,6</sup> Prior observational studies have shown that hypertension is more common and more poorly controlled among lower versus higher SES groups.<sup>7,8</sup> However, understanding the causes of such disparities remains a challenge within public health. There are multiple factors including the lack of access to appropriate hypertension treatment that may explain why lower SES is associated with lower blood pressure control and increased risk of outcomes. It remains unclear whether these associations persist when the lack of access to appropriate hypertension treatment is no longer a barrier.

In this issue of the *Journal of the American Heart Association (JAHA)*, Shahu et al address this knowledge gap by examining the associations of household income with blood pressure control and outcomes including CVD events and all-cause mortality in a post hoc analysis of ALLHAT

(Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial).<sup>9</sup> ALLHAT, one of the largest double-blinded randomized trials of antihypertensive medication treatment, enrolled men and women  $\geq 55$  years old with untreated or treated hypertension, and prior history of CVD or 1 or more CVD risk factors.<sup>10</sup> Randomization occurred within study sites and participants were initially assigned to a thiazide diuretic (chlorthalidone), an angiotensin-converting enzyme inhibitor (lisinopril), a calcium channel blocker (amlodipine), or an alpha-adrenergic blocker (doxazosin). Second-line medications (atenolol, clonidine, or reserpine) and third-line medications (hydralazine) could be added after the initial medications were titrated to the maximum dose. The doxazosin treatment arm, which was prematurely terminated because chlorthalidone was found to be superior to doxazosin, was not included in the current analysis.<sup>11</sup>

The analysis by Shahu et al was restricted to sites located in the continental United States (US). Household income was defined as the county-level median household income of a participant's study site, which was based on study site zip codes. The authors determined county-level median household income from the 2000 US Census, which was the closest census year to the ALLHAT study period. County-level income was adjusted for the cost of living in each state in 2000 and then assigned to participants at that site. Using data from 27 862 ALLHAT participants, the authors found that the lowest quintile, compared with the highest quintile of household income, had significantly worse blood pressure control, defined as a blood pressure  $< 140/90$  mm Hg, at year 1 follow-up (44.8% versus 57.3%, respectively), which persisted to year 6 follow-up (50.0% versus 69.3%, respectively). The adjusted odds ratio (95% CI) for blood pressure control was 0.62 (95% CI, 0.56–0.70) at year 1 and 0.48 (95% CI, 0.37–0.63) at year 6. Additionally, the lowest versus highest quintile of household income had an increased risk of all-cause mortality (adjusted hazard ratio 1.25; 95% CI, 1.10–1.41), hospitalized or fatal heart failure (adjusted hazard ratio, 1.26; 95% CI, 1.03–1.55), and end-stage renal disease (adjusted hazard ratio 1.86; 95% CI, 1.26–2.73).

The analysis<sup>9</sup> has several notable strengths. Participants were enrolled into a highly standardized trial that had a rigorous study protocol including the conduct of research grade blood pressure measurements, administration of

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antihypertensive medication along with a standardized approach to medication titration, and regular and frequent follow-up visits. These findings indicate that low SES, as represented by household income, was associated with worse blood pressure control and an increased risk of outcomes in an environment that provided access to uniform hypertension treatment for all participants, regardless of SES. Furthermore, for blood pressure control, the results were consistent across several sensitivity analyses including stratification by treatment arm, and restriction to black participants, and separately to participants living in the South. Finally, results for blood pressure control were also similar after adjusting for visit adherence. This is a particularly important consideration because visit adherence was lowest among participants in the lowest quintile of household income.

Examining the associations of household income with blood pressure control and outcomes within the context of a clinical trial is novel. However, to understand the implications of the study findings requires an appreciation of some potential study limitations. Median household income of the county in which a study site was located may not be equivalent to the median household income of the county where the participant lived nor the income of a participant's household. Furthermore, household income may not fully capture disparities in net worth or financial security of a household or community, which may better align with the health disadvantages of poverty.<sup>12</sup> Similarly, the study was unable to examine other SES factors, such as educational attainment, and how they may affect the associations found by the authors. Lifestyle factors including healthy diet, physical activity, and weight loss, which are important in blood pressure control, were not examined in this study.<sup>13</sup> In ALLHAT, adoption of healthy lifestyle factors were "encouraged" for all participants; however, it is unknown how adherence to such recommendations varied between income groups. It is possible that participants in the lowest quintile of household income were less likely to adhere to a healthy lifestyle.<sup>13</sup> The analyses were also unable to adjust for antihypertensive medication adherence, because of a substantial amount of missing data. Finally, the analyses were not able to investigate the dynamic means by which low income, inadequate education, job insecurity, housing insecurity, and other social threats to health may interact to affect an individual over their life course.

There were also some unexpected findings. Compared with the highest quintile of household income, the lowest quintile of household income was not associated with an increased risk of combined fatal coronary heart disease or nonfatal myocardial infarction, which was the primary outcome assessed in ALLHAT. Similarly, the lowest quintile of household income was not associated with an increased risk of stroke; fatal, hospitalized, or treated nonhospitalized heart

failure; and peripheral artery disease. It is unclear why there was an inconsistent association between household income and CVD events. Furthermore, the study did not examine whether the associations of the lowest quintile of household income with the increased risks of all-cause mortality, hospitalized or fatal heart failure, and end-stage renal disease were explained by worse blood pressure control. Therefore, whether the effects of SES on these outcomes were mediated by the effects of SES on blood pressure is unknown. Finally, the lowest quintile of household income was associated with a lower risk of coronary revascularization, and hospitalized or treated angina. Reasons for these findings are unknown, and should be investigated further. As the authors suggested, it is plausible that the participants in the lowest quintile of household income did not seek medical evaluation, had atypical presentations, and/or were treated differently than those in the highest quintile of household income.<sup>14</sup>

Recent data from the National Health and Nutrition Examination Survey indicate that the prevalence of controlled hypertension remains at  $\approx 50\%$ .<sup>15</sup> Based on the 2017 American College of Cardiology/American Heart Association Blood Pressure guideline, which recommends a lower blood pressure threshold ( $\geq 130/80$  mm Hg) for defining hypertension, 45.6% of US adults have hypertension.<sup>16</sup> Among US adults taking antihypertensive medication, 53.4% had blood pressure above the treatment goal according to this threshold.<sup>16</sup> These findings suggest that more intensive efforts are needed to improve blood pressure control among the general population. The findings by Shahu et al indicate that it is particularly important that SES be considered when treating patients with hypertension. If lack of access to hypertension treatment fully explains income-related disparities in blood pressure control and outcomes, we would have expected these disparities to be mitigated within the context of a clinical trial. Therefore, the study by Shahu et al<sup>9</sup> confirms the complexity of the associations of disparities in income with blood pressure control and hypertension-related outcomes, and suggests that providing access to hypertension treatment alone may be insufficient to overcome this inequity. As such, more research needs to be conducted to determine the underlying mechanisms and how they relate to one another.

In summary, in exposing the associations of lower household income with worse blood pressure control and outcomes among participants enrolled in a rigorous clinical trial, Shahu et al<sup>9</sup> have revealed the challenges of fully understanding the link between lower SES and adverse health. That such disparities in health are as apparent currently<sup>1,7-9,12,17</sup> as they were at the time of the Whitehall studies several decades ago<sup>2,3</sup> underscores the urgent need to understand the root causes of such social inequities and to overcome them. Finally, as we implement strategies to improve blood pressure control,<sup>6</sup> it is essential that we actively account for the

potential harms to health associated with low SES, to ensure that the care we deliver improves outcomes for all populations.

## Disclosures

None.

## References

- Schultz WM, Kelli HM, Lisko JC, Varghese T, Shen J, Sandesara P, Quyyumi AA, Taylor HA, Gulati M, Harold JG, Mieres JH, Ferdinand KC, Mensah GA, Sperling LS. Socioeconomic status and cardiovascular outcomes: challenges and interventions. *Circulation*. 2018;137:2166–2178.
- Marmot MG, Shipley MJ, Rose G. Inequalities in death—specific explanations of a general pattern? *Lancet*. 1984;1:1003–1006.
- Marmot MG, Smith GD, Stansfeld S, Patel C, North F, Head J, White I, Brunner E, Feeney A. Health inequalities among British civil servants: the Whitehall II study. *Lancet*. 1991;337:1387–1393.
- Collaborators GBDRF. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2018;392:1923–1994.
- Rapsomaniki E, Timmis A, George J, Pujades-Rodriguez M, Shah AD, Denaxas S, White IR, Caulfield MJ, Deanfield JE, Smeeth L, Williams B, Hingorani A, Hemingway H. Blood pressure and incidence of twelve cardiovascular diseases: lifetime risks, healthy life-years lost, and age-specific associations in 1.25 million people. *Lancet*. 2014;383:1899–1911.
- Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, MacLaughlin EJ, Muntner P, Ovbigele B, Smith SC Jr, Spencer CC, Stafford RS, Taler SJ, Thomas RJ, Williams KA Sr, Williamson JD, Wright JT Jr. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Hypertension*. 2018;71:e13–e115.
- Odutayo A, Gill P, Shepherd S, Akingbade A, Hopewell S, Tennankore K, Hunn BH, Emdin CA. Income disparities in absolute cardiovascular risk and cardiovascular risk factors in the United States, 1999–2014. *JAMA Cardiol*. 2017;2:782–790.
- Beckman AL, Herrin J, Nasir K, Desai NR, Spatz ES. Trends in cardiovascular health of US adults by income, 2005–2014. *JAMA Cardiol*. 2017;2:814–816.
- Shahu A, Herrin J, Dhruva S, Desai N, Davis B, Krumholz H, Spatz E. Disparities in socioeconomic context and association with blood pressure control and cardiovascular outcomes in the Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). *J Am Heart Assoc*. 2019;8:e012277. DOI: 10.1161/JAHA.119.012277.
- Davis BR, Cutler JA, Gordon DJ, Furberg CD, Wright JT Jr, Cushman WC, Grimm RH, LaRosa J, Whelton PK, Perry HM, Alderman MH, Ford CE, Oparil S, Francis C, Proschan M, Pressel S, Black HR, Hawkins CM. Rationale and design for the Antihypertensive and Lipid Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). ALLHAT Research Group. *Am J Hypertens*. 1996;9:342–360.
- Officers A, Coordinators for the ACRGTA and Lipid-Lowering Treatment to Prevent Heart Attack T. Major outcomes in high-risk hypertensive patients randomized to angiotensin-converting enzyme inhibitor or calcium channel blocker vs diuretic: the Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). *JAMA*. 2002;288:2981–2997.
- Bor J, Cohen GH, Galea S. Population health in an era of rising income inequality: USA, 1980–2015. *Lancet*. 2017;389:1475–1490.
- Pampel FC, Krueger PM, Denney JT. Socioeconomic disparities in health behaviors. *Annu Rev Sociol*. 2010;36:349–370.
- Anstey DE, Li S, Thomas L, Wang TY, Wiviott SD. Race and sex differences in management and outcomes of patients after ST-elevation and non-ST-elevation myocardial infarct: results from the NCDR. *Clin Cardiol*. 2016;39:585–595.
- Fryar CD, Ostchega Y, Hales CM, Zhang G, Kruszon-Moran D. Hypertension prevalence and control among adults: United States, 2015–2016. *NCHS Data Brief*. 2017;289:1–8.
- Muntner P, Carey RM, Gidding S, Jones DW, Taler SJ, Wright JT Jr, Whelton PK. Potential US population impact of the 2017 ACC/AHA high blood pressure guideline. *Circulation*. 2018;137:109–118.
- Chetty R, Stepner M, Abraham S, Lin S, Scuderi B, Turner N, Bergeron A, Cutler D. The association between income and life expectancy in the United States, 2001–2014. *JAMA*. 2016;315:1750–1766.

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