By David H. Rehkopf, Sepideh Modrek, Linda F. Cantley, and Mark R. Cullen

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Social, Psychological, And Physical Aspects Of The Work Environment Could Contribute To Hypertension Prevalence

David H. Rehkopf (drehkopf@stanford.edu) is an assistant professor in the Division of General Medicine Disciplines at Stanford Medicine, Stanford University, in California.

Sepideh Modrek is an assistant professor in the Department of Economics, College of Business, at San Francisco State University, in California.

Linda F. Cantley is a lecturer at the Yale University School of Medicine, in New Haven, Connecticut.

Mark R. Cullen is a professor in the Division of General Medicine Disciplines, Stanford Medicine, Stanford University.

ABSTRACT Studies on the physical and social characteristics of the workplace have begun to provide evidence for the role of specific workplace factors on health. However, the overall contribution of the workplace to health has not been considered. Estimates of the influences on health across domains of the work environment are a critical first step toward understanding what level of priority the workplace should take as the target for public policies to improve health. The influences or contribution of these domains on health in the work environment are particularly useful to study since they are potentially modifiable through changes in policies and environment. Our analysis used detailed data from blue-collar industrial workers at two dozen Alcoa plants. It includes work environmental measures of psychological hazards, physical hazards, and the workplace social environment, to estimate the overall importance of the workplace environment for hypertension. Our findings suggest that social, psychological, and physical aspects of the work environment could contribute to a substantial proportion of hypertension prevalence. These attributes of the workplace could thus be a useful target for improving workforce health.

Hypertension is among the most important modifiable risk factors for myocardial infarction worldwide[1] and contributes to one out of every seven deaths in the United States.[2] While clinical intervention with medication is the primary approach to controlling hypertension,[3] the importance of lifestyle modification is emphasized for primary prevention. Prevention recommendations currently focus on dietary and physical activity interventions.[4] Yet despite the pharmaceutical tools available and knowledge of which behavioral risk factors should be targeted, data on the US population since 1999 show no progress toward the Healthy People 2020 goal of decreasing hypertension prevalence to 26.9 percent.[5] Additional complementary approaches to making progress in reducing hypertension use the fact that behaviors are influenced by environmental context—thus, changes to the environment are gaining increased attention as a strategy for improving population health and reducing health care costs.[6,7]

A promising environment to target is the workplace, given the large and consistent duration of time spent in this environment over an individual's lifetime. It also is promising as a realistic location for interventions, as management interests might be leveraged to make workplace changes that could improve worker productivity, reduce sick time, and reduce health care costs.[8] Thus far, workplace interventions to decrease chronic disease risk have primarily been focused on targeting health behaviors such as increasing physical activity; these have shown

some benefits.[9] An additional approach to targeting the workplace to improve health and reduce hypertension could entail the mitigation of aspects of the work environment proven to influence hypertension. The literature can be divided into three domains of exposures: psychological hazards, physical hazards, and workplace social environment. Within the domain of psychological hazards, factors include how often your job requires you to work fast, as well as the degree to which workers are enabled to make decisions.[10] Within the domain of physical hazards, exposure to heat and vibration may have implications for health, including for hypertension.[11,12] Exposure to fine particulate matter—tiny droplets or particles in the air linked with air pollution and lung disease—associated with increased ischemic heart disease[13] is also included. Associations between hypertension and myriad workplace chemicals such as heavy metals have also been suggested[14] but were not included here because they typically affect much smaller segments of the workforce. Finally, the domain of workplace social environment may also play a role in hypertension. Features of this domain include recognition of employees for their work and attitudes toward management, some of which come under the larger umbrella of workplace well-being.[8]

Yet despite a large literature on the importance of specific factors within these three domains of the workplace for health, few studies have simultaneously considered multiple workplace environmental exposures to shed light on how these factors potentially contribute overall to hypertension.

To address this question, we used a unique administrative data set covering the employees of Alcoa, a large US manufacturing company, for which we have both individual-level and plant-level measures. While many prior studies have used only individual-level subjective reports of the environment to define exposures, interpretation of this type of measure could be problematic because results could be biased by the health and psychological characteristics that influence reporting.[15] In this study, workplace assessments of physical and psychological hazards were assessed in a job-specific manner by a health or safety officer at the plant who was familiar with the characteristics of each job. We assessed the plant's social environment by aggregating workers' reports into an overall environment measure. A strength of our data was that all members of this workforce had high-quality health insurance, so any correlations we observed between workplace environment and hypertension were unlikely to be attributable to differences in insurance coverage.

In addition to workplace exposures, we linked these workers to attributes of their current state of residence and early-life state of residence, since characteristics of the broader environment, whether at the level of state, county, or neighborhood, account for a meaningful amount of chronic disease.[16–23]

Our goal was to describe the patterns of association between characteristics of the work environment and hypertension. We analyzed the strength of association among twenty-four different workplace and state-of-residence characteristics and hypertension. Within the workplace, we examined two factors that related to the psychological hazards domain, six factors that were within the domain of physical hazards, and four factors that captured the domain of workplace social environment. For comparison to the broader social environment and some social determinants of health, we also examined six characteristics of the workers' current state of residence and six characteristics of their early-life state of residence.

Study Data And Methods

DATA SOURCE The Alcoa cohort is a longstanding academic-corporate partnership formally initiated in 1997, which has collected data on all workers from the Alcoa aluminum manufacturing company. The Alcoa workforce has been well characterized through a large number of studies in the medical and economics literature.[24–29] The current study used data from twenty-four manufacturing plants with the most detailed work context data, yielding a total analytic sample size of 13,978 individuals. We also analyzed a subset of this cohort with more detailed assessments to examine physical and psychological hazards on workers at eight manufacturing plants that included 6,535 individuals. Data were collected for administrative purposes on all employees beginning in 1996 through their date of retirement or the end of 2012.

We used these administrative records to obtain individual-level covariates and outcome data. These data included age, race, and gender. We linked employees to W2 earnings records and had an administrative measure of job grade to capture the level of skill and responsibility for that job that ranged from 1 to 65. For our analyses, we used the average earnings and grade per year across all observed years. Prevalence of hypertension was defined as having two or more diagnoses during the years of observation (4,388 individuals out of 13,978 among the 24 plants and 2,310 individuals out of the 6,535 among the smaller subset of 8 plants had prevalent hypertension). Although it was a limitation to use medical billing records of hypertension diagno-

ses as compared to having physician-diagnosed hypertension, prior work has determined the accuracy of medical claims data for identifying health outcomes from administrative data.[30–32] Online Appendix section 11 shows that results did not differ meaningfully for most of the exposures when a stricter definition of hypertension (four diagnoses instead of two) was used.[33]

Measures of the workplace social environment came from employees' responses to an anonymous in-plant survey obtained in 2006; this survey was used to create four factors (see Appendix section 4.)[33] The first factor was how individuals felt overall about the company. The second concerned work-life balance. The third was whether the employee had a good relationship with his or her supervisor. The fourth was whether there was meaningful recognition of employees' efforts in the workplace. The mean response among hourly workers to each of these constructs was created per plant to capture the nature of the workplace environment, instead of as an individual perception of the work environment.

A job demands survey was used to collect information about the requirements of different jobs (see Appendix section 3).[33] Measures of the physical and psychological demands of a job were evaluated by a health or safety officer at the plant with detailed knowledge of job characteristics, including how sedentary the job was, the amount of vibration encountered in plant equipment, the amount of dynamic movement required, and the amount of reaching to meet the demands of the job. An additional question assessed how much heat exposure was associated with the job (see Appendix section 4 for additional details).[33] We also incorporated more than 8,000 current and historical measurements of particulate-matter exposures and assigned these to individuals using a job exposure matrix.[13,34] Psychological demands included how fast an employee was required to work, how often an employee had to work without making mistakes, and whether an employee had to perform multiple tasks simultaneously that were difficult to combine.

ANALYSIS The six state variables captured key aspects of the social and economic environment of the state the individual grew up in and where they lived at the time of the study. These variables included the Gini coefficient, which is a measure of income inequality, as well as, at the state level, the level of education, median income, level of unemployment, percentage of the population that is white, and percentage of the population that is living in urban areas.

We used regression modeling to examine how each of the twenty-four factors was associated with prevalent hypertension, controlling for the additional individual-level factors of age, age-squared, black race, Latino ethnicity, gender, smelter type of plant, earnings, and job grade. We also ran additional models controlling for years of cigarette smoking, body mass index (BMI) (based on measured height and weight during medical examinations), and baseline health risk score (see Appendix section 8).[33] The baseline health risk score was based on medical claims data[35] and was an overall aggregated measure of health based on the number and type of medical claims for that individual in each year. For the variables that were time varying (earnings, BMI, health risk score, job grade, and years of cigarette smoking), we used the average over the study period, with the source and years of data described in the Appendix.[33]

Second, we calculated a population-attributable fraction for the sum of the predictors within each of the five domains, taken from a single regression model fitted for each category, controlling for age, age-squared, black race, Latino ethnicity, gender, smelter type of plant, earnings, and job grade (see Appendix section 12 for details of this calculation).[33]

LIMITATIONS There were important limitations to our data and analysis. First, the relative comparison of the strength of association between each of these factors depended on how well each was measured. While a strength of the data was that all were reasonably well measured and all factors were standardized for comparability of strength of association, this remains a limitation of all such comparative work. In addition, all of the data we present were based on cross-sectional associations. Intervening on a particular factor might not have an impact on hypertension, but understanding the strength of association is a first step toward intervention studies to evaluate the effects of factors within the domains we examined. While all of our analyses were prespecified and reported, regardless of findings, which reduced some sources of bias,[36] we were unable to estimate the effects of actual workplace changes from this study. Finally, these data were of a subset of Alcoa workers in twenty-four manufacturing plants (eight manufacturing plants for the analyses of physical and psychological hazards). How they were affected by the work environment might be different from how work environment affected other manufacturing workers. In addition, the range of exposures experienced by workers within a single firm could be less than the spectrum of manufacturing workers in the general US population, thus likely underestimating strengths of association.

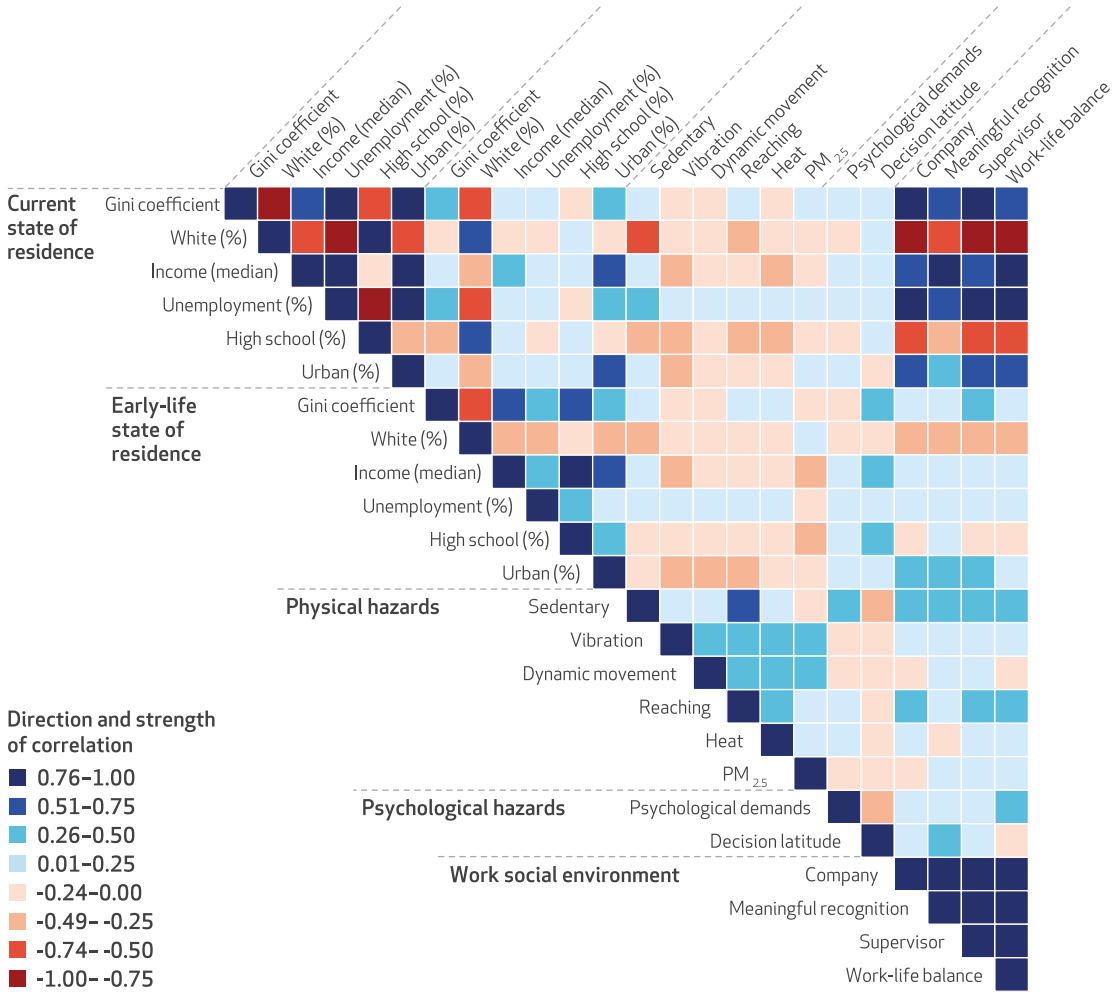
Study Results

We examined how closely related each of our workplace context and state context measures were with each other (Exhibit 1). Correlations between factors can be found by following a row label to where it meets a column label (or column label to a row label). The darker the blue square, the more positive the correlation, while the darker red dots indicate a more negative correlation. Many of the relationships shown on the grid are light in color, which indicates that many of these factors are not highly correlated with each other. This is important for policy considerations because it implies that the work environment does not overlap with broader geographic contextual characteristics and that even within the workplace, the social, psychological, and physical contexts represent unique avenues for potential interventions to improve health.

We calculated correlation estimates from regression models for how strongly each of the twenty-four factors within the domains of current state of residence, early-life state of residence, physical hazards, psychological hazards, and workplace social environment were associated with hypertension, statistically controlling for demographic and socioeconomic factors. Exhibit 2 shows dots that depict the strength each factor's association with hypertension (the Appendix shows the exact estimates of the

EXHIBIT 1

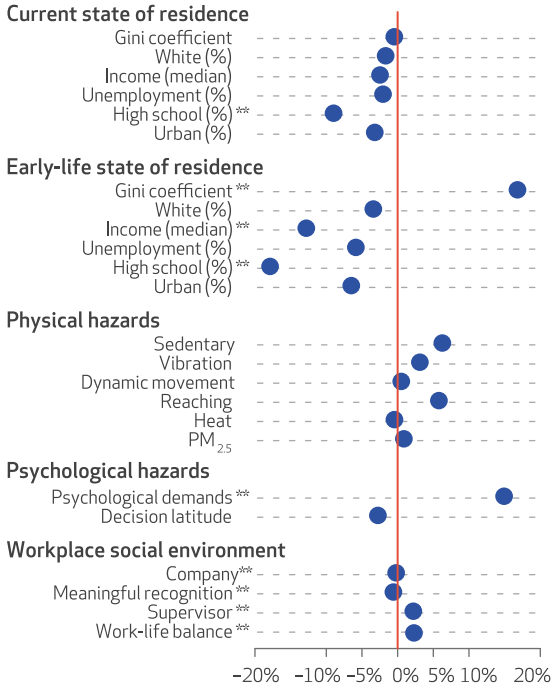
Relatedness of state and work environments and individual workplace exposures with hypertension



SOURCE Authors' calculations of data from Alcoa employees, 1996–2012. **NOTES** The strength of correlation between any two exposures can be found by picking one exposure of interest in the column or row label, then picking a second exposure of interest as the complementary row or column label, and finding the space where the column and row meet. Dark blue indicates a full positive correlation and dark red indicates a full negative correlation, with gradations between 1 and –1 as categories as shown in the scale. $N = 6{,}535$. "Urban" is the percentage of state population living in urban areas. "Reaching" is the amount of time in a job in which an employee is required to bend or extend arms. "Company" refers to employees having positive feelings about the company. $PM_{2.5}$ is particulate matter that is 2.5 micrometers in diameter or smaller.

EXHIBIT 2

Independent strength of association of state and work environments and individual workplace exposures with hypertension



SOURCE Authors' calculations of data from Alcoa employees, 1996–2012. **NOTES** Dots indicate strength of association with clinically diagnosed hypertension (two or more diagnoses) with statistical control for age, age-squared, black race, Latino ethnicity, gender, smelter-type plant, mean earnings, and mean employment grade. All variables shown are standardized to a scale in which 1 is equal to a standard deviation for that variable so that coefficients can be compared between measures. Values thus show the difference in prevalence of hypertension associated with a 1-standard-deviation higher value of that factor. The null relationship at 0 is shown as the vertical red line. $N = 13{,}978$ for current state of residence, early-life state residence, and workplace social environment; $N = 6{,}535$ for physical hazards and psychological hazards. $PM_{2.5}$ is particulate matter that is 2.5 micrometers in diameter or smaller. Significance denotes difference after accounting for twenty-four comparisons. ** $p < 0.05$

coefficients along with p values corrected for multiple comparisons).[33] Two asterisks after the variable name indicates associations statistically significant at $p < 0.05$ after multiple comparisons were accounted for. The red line indicates no association, dots to the right of the red line indicate that higher levels of the factor are associated with more hypertension, and dots to the left of the line show that a higher level of the factor is associated with a lower level of hypertension.

Within the categories of current and early-life state of residence, the strongest predictors of hypertension prevalence were living, early in life, in a state with a high level of income inequality (Gini coefficient) and with fewer individuals with a high school education. Most of the hazards measured in the physical environment, including working in a job that was sedentary or required more frequent reaching, were associated with higher levels of hypertension, but these associations were not statistically significant. Within psychological hazards, a job that is structured to have a 1-standard-deviation-higher level of psychological demands is associated with approximately a 15 percent higher risk of hypertension. Within the category of workplace social environment, better impressions of the company and more meaningful recognition were associated with lower hypertension, while positive feelings about the supervisor and work-life balance were associated with greater hypertension.

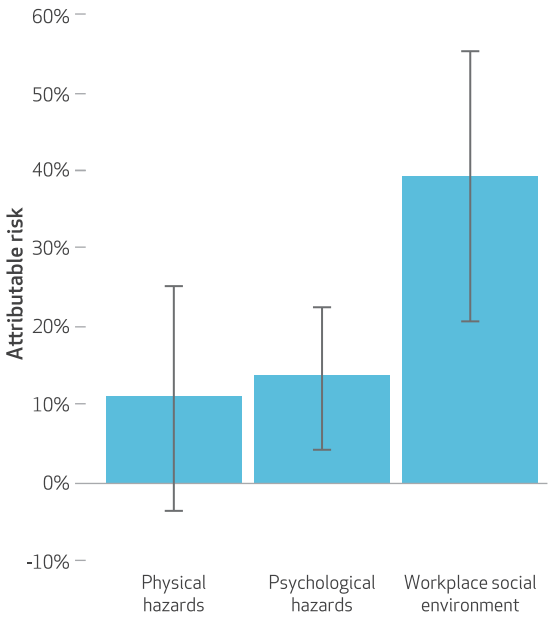
We also calculated the proportion of population hypertension that could be prevented if each of the individuals experiencing hazardous levels of an exposure were instead assumed to have a level of exposure 1 standard deviation below the mean (or in the case of beneficial factors, 1 standard deviation above the mean). Among workplace categories, the greatest amount of hypertension could be prevented with interventions on the plant social environment, although there were also potential impacts within the categories of psychological hazards and physical hazards, within the confidence intervals of the workplace social environment (Exhibit 3). To put these preventable fractions of hypertension in perspective, setting BMI levels greater than 25 kg/m^2 (overweight) is associated with a 48 percent attributable fraction (95% confidence interval: 45, 51) for hypertension.

Discussion

Our findings demonstrate that workplace environmental exposures may as a whole contribute substantially to hypertension among US blue-collar workers. We found evidence for this across multiple exposures in the categories of psychological hazards and the plant social environment. Our analysis represents a comprehensive look at simultaneously considering features of the physical and social workplace environment. We compared these associations to current and early-life state environments, which were previously demonstrated to be contexts associated with health, including hypertension. We used measures that were focused primarily on the plant and on job characteristics instead of the attributes of individuals. Thus, our analysis was specific to the associations with how jobs and workplaces were structured and organized. We believe that this is a critical step for prioritizing more-targeted future studies of work environments and for prioritizing a research agenda

EXHIBIT 3

Population-attributable fraction for hypertension of each category of the workplace



SOURCE Authors' calculations of data from Alcoa employees, 1996–2012. **NOTES** Bars show 95% bootstrap confidence intervals of the attributable risk estimates. Models include statistical control for age, age-squared, black race, Latino ethnicity, gender, smelter-type plant, earnings, and employment grade. The baseline for the attributable risk calculations were values 1 standard deviation below the median for hazards and 1 standard deviation above the median for factors associated with lower hypertension. $N = 13{,}978$ for workplace social environment; $N = 6{,}535$ for physical hazards and psychological hazards.

for such exposures.

We found that being in a job that was classified as having a higher level of psychological demands was associated with higher levels of hypertension. This finding is consistent with a large literature showing how hazardous psychological demands in the workplace are associated with greater hypertension.[10] A recent individual-level meta-analysis of 13 studies with 200,000 individuals showed that the job strain measure of work stress was associated with greater incident of coronary heart disease,[37] and a meta-analysis of 29 studies showed associations with increased hypertension.[38] Other findings in the Alcoa population also showed that higher psychological demand was associated with greater risk of serious injury.[39]

We found that within the workplace social environment, at plants where there was an aggregated hourly worker report of more positive feelings toward the company and more meaningful recognition of work, there was a lower prevalence of hypertension. Counter to our hypotheses and prior work,[40] we found that a better work-life balance and a positive report of supervisors were associated with higher levels of hypertension. In interpreting these findings, it is important to emphasize that while the basis for these metrics was individual employee surveys, we aggregated hourly workers' responses to the level of the plant to capture environmental differences (instead of individual perceptions) of how the environment varied between plants. Unlike most of the other constructs that we examined in this study, our measures of attitude toward the company, meaningful recognition, and feelings about the employee's direct supervisor were highly correlated, thus generally capturing a single aspect of the plants that we examined. Thus, these findings should be interpreted in terms of a plant-level environmental exposure, or plant culture. A particular advantage of the Alcoa study that allowed us to do this was having a large number of respondents within each plant to have stable estimates and also having sufficient variation in the work environment between plants within the company (see Appendix section 6).[33] While we can make no firm conclusions about the reason for these associations, the fact that the population impact of these exposures is large for hypertension suggests the need for research into understanding how to actually intervene to change plant culture in ways that improve hypertension.

Each of the factors that we examined were related to small differences in the prevalence of hypertension, with the majority of associations within a magnitude of a 5 percent difference in prevalence based on a standard deviation difference in the environmental factor. It is worth considering the relevance of this difference for health. Each of these factors, if considered in isolation, represents small differences as compared to other individual-level demographic and behavioral risk factors for hypertension. But in the context of other workplace interventions, such policies have the potential to have a meaningful impact. This is demonstrated most clearly by the attributable risk estimates within domains (Exhibit 3). Unlike individual risk factors that may affect only a small proportion of the population, all workers are exposed to both a physical and a social environment; thus, even if the relative risk of an exposure is small, the possibility for population impact is larger than for a rare risk factor.[41]

In addition, unlike demographic risk factors for hypertension such as age, race, and gender, aspects of the work environment can be influenced and changed. It is an open question whether workplace characteristics are easier to change than individual health behaviors—each is a challenge for different reasons. However, the sub-

stantial level of regulations around work conditions of the physical environment suggest that regulatory action in this domain is possible, although the level of evidence for ties between the social environment and health outcomes such as hypertension should be further substantiated with evidence to support such policies. Until the time such evidence is obtained, workplaces could take steps independently to improve working conditions consistent with our evidence—and follow up with evaluations of these changes' effects.

While we did not find that factors within the domain of the physical environment had statistically significant associations with hypertension, this does not mean that this domain of exposures is not important. First, measures of being sedentary and having higher levels of exposure to vibration and reaching were all associated in the expected direction with higher levels of hypertension, and the overall attributable fraction was 11 percent. In addition, these factors may have other health consequences instead of hypertension. For example, previous work in this cohort has demonstrated an association of fine particulate matter ($PM_{2.5}$, or particulate matter that is 2.5 micrometers in diameter or smaller) with ischemic heart disease.[13] Finally, these factors in the physical environment could have particularly damaging impacts on subgroups of the population,[42] even if they do not, on average, have a meaningful magnitude of effect.

Conclusion

Reducing the prevalence of hypertension will likely require sustained efforts that include strategies that complement but also go beyond direct pharmaceutical treatment and education about a healthy lifestyle—the two primary approaches to addressing hypertension in the United States. To be successful, policy makers should consider multiple strategies for intervening on environments that may contribute to hypertension. One potential such environment is the workplace.

The Healthy People 2020 goal of reducing hypertension from 29.9 percent of the population in 2005–08 to 26.9 percent by 2020 is based on achieving a 10 percent reduction in prevalence. Our findings of attributable risk for workplace social environment, physical hazards, and psychological hazards suggest that interventions targeting aspects of the work environment within each of these domains could help achieve Healthy People 2020 goals for middle-class blue-collar workers. Current workplace regulation has focused primarily on physical hazards and less so on the social aspects and psychological hazards of the workplace, despite substantial evidence in each of these areas demonstrating their influence on workplace health. We showed that these risks were not likely to be highly correlated within individual blue-collar workers—some were more highly exposed to physical risks, others to psychological and social risks. Because our findings did not test actual specific interventions, our results do not guide specifically what actions should be taken. There are, however, large literatures within each of the domains we investigated focused on specific targets for intervention.[43] The conclusion from our findings is rather that these broader aspects of the work environment, taken together, represent a potentially large burden contributing to hypertension—one of the most important risk factors for cardiovascular disease. Policy makers should consider supporting the evaluation of interventions within these domains to develop workplace-based strategies for reducing hypertension. ■

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NOTES

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