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How Cumulative Risks Warrant A Shift In Our Approach To Racial Health Disparities: The Case of Lead, Stress, and Hypertension

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Abstract

Blacks have persistently higher rates of high blood pressure, or hypertension, compared to whites, resulting in higher health costs and greater mortality. Recent research has shown that social and environmental factors – such as high levels of stress and exposure to lead – may explain racial disparities in hypertension. Based on these findings, we recommend a fundamental shift in approaches to health disparities to focus on these sorts of cumulative risks and health effects. Federal and state agencies and research institutions should develop strategic plans to learn more about these connections and apply the broader findings to policies to improve health disparities.

Health disparities between black and white Americans are stark and well-documented – the central reason that the Department of Health and Human Services’ “Healthy People 2020” agenda gives national priority to eliminating them.[1,2] When attempting to clarify the causes of these disparities, most research is focused on health behaviors or genetics, but social and environmental factors are important as well.[2-4]

Although research into “environmental justice”—reducing the inequitable distribution of environmental hazards—has documented persistent racial disparities in exposure to environmental hazards,[5,6] few studies have integrated environmental justice with health disparities research to examine how they are linked.[3,4,7] Adding to the complexity is new research showing that social and nutritional factors increase vulnerability to the harmful effects of environmental exposures.[8-10] Because there are racial disparities in many of these factors, this collective body of information challenges researchers and policy makers to view the causes of and remedies for health disparities in a fundamentally new way.

We argue for a fundamental shift in the approach to racial health disparities that accounts for the cumulative burden of social and environmental disparities among races. We lay out our argument in two sections. First, using lead and hypertension as an example to guide our navigation through the literature, we synthesize numerous research lines generally not examined together. We discuss new research into how stress modifies the hypertensive effects of lead. For example, in a 2007 report, researchers showed that men who reported high levels of stress had a stronger association between lead and hypertension compared to men who reported low levels of stress.[9]

Using this multidisciplinary approach, we shed new light on potential determinants of health disparities that have received little attention in research, clinical, or policy arenas.

In the second section, we provide specific research and policy recommendations based on our synthesis of the research. We call for research and policy initiatives based on a framework that assumes that health risks, and therefore health impacts, can accumulate in the ways described. This framework encompasses the notion that the quality of many social and environmental factors is often spatially correlated and may act synergistically to produce and maintain health disparities.[11,12] In other words, those communities that experience high exposure to environmental hazards are also more likely to be the communities that experience poor social circumstances such as poverty or lack of access to healthy food. These social and environmental factors may act together to result in health disparities. Ultimately, full understanding and addressing these cumulative effects will require interdisciplinary and interagency collaboration.

We highlight the recent progress made by the Environmental Protection Agency (EPA) in using this framework to eliminate racial health disparities, an effort which will then serve as a model for other agencies. We echo the sentiments of the National Environmental Justice Advisory Council of the EPA that this new approach is the “fastest and surest way to bring about tangible and sustainable benefits”[12] toward the elimination of health disparities, which has the potential to substantially lower health care costs and improve the lives of vulnerable populations.[13]

Lead, Hypertension, And Race

Blacks have persistently higher rates of hypertension compared to whites.[2] A 2010 American Heart Association report put nationwide prevalence estimates at roughly 33 percent for whites but 43 percent for blacks.[14] These findings have important ramifications for health disparities overall, as hypertension is linked to increased risk of other diseases and mortality.[15] Researchers estimated that between 1990 and 2000, roughly 890,000 blacks would have been saved if blacks had the mortality rate of whites. [16] Furthermore, the disparities in hypertension account for the most years of lost life compared to *any* other health condition with disparities.[17] This means that addressing the hypertension disparities would substantially contribute to reducing deaths among blacks.

Blacks have also historically experienced more environmental lead exposure compared to whites. For example, during the period 1976-80, roughly 23 percent of blacks had blood lead levels (a common method to measure lead body burden, marking short-term, recent exposure) greater than 20 micrograms of lead per deciliter of blood—a level considered to be high -- compared to only 14 percent of whites.[18] This is troubling not only because lead remains in the body for decades, as we will discuss, but because the deleterious health effects of lead in adults, for which there are marked racial disparities, have been documented at levels substantially lower than 20 micrograms per deciliter.[19,20]

Meanwhile, blood lead levels have declined for all Americans since the implementation of policies directing removal of leaded gasoline and other leaded products from the market beginning in the 1970s.[21] In fact, from 1999 to 2002, blood lead levels higher than 20 micrograms per deciliter were rare enough not to be reported in nationwide estimates.[19]

Although current blood lead levels are generally low for Americans, lead continues to be an important environmental hazard for adults, particularly for racial minorities. Historical disparities in lead exposure are important as our bones store lead for decades, making bone lead a potential internal exposure source, particularly during times of bone loss such as pregnancy and menopause, long after external exposures have abated.[22-24] Although there is a dearth of data on bone lead in nonwhites, the few existing data suggest that there are larger racial disparities in bone lead compared to blood lead in adults, reflecting the

historical disparities in lead exposure.[25,26] Also, higher levels of lead continue to be more prevalent in disadvantaged—including black—populations than in advantaged populations. [19,26] Finally, new research suggests that certain social factors that are more prevalent in black communities may amplify the hypertensive effects of low levels of lead.[8,9]

A growing body of research indicates that lead exposure is causally related to a modest increase in both blood pressure and hypertension.[27,28] Evidence suggests that the consequences of this effect are substantial, as hypertension is the leading cause of mortality resulting from cardiovascular disease. In 2009, researchers reported on the association between bone lead and mortality due to cardiovascular disease. Men with the highest levels of bone lead had more than five times the risk of dying of cardiovascular disease compared to men with the lowest levels of bone lead.[29]

Research suggests that race modifies this association between lead body burden and blood pressure and hypertension. Using nationally representative data from the period 1999-2002, researchers reported that whites do not exhibit this relation between blood lead levels and blood pressure.[19,30] On the other hand, systolic blood pressure in blacks increases roughly one millimeter of mercury for each doubling of blood lead level, even after adjusting for numerous confounders such as age, smoking, and body mass index (a measure of obesity).[30] Blacks, but not whites, also show an association between blood lead and hypertension. Using the same 1999-2002 data, blacks with the highest blood lead levels show 44 percent greater odds of hypertension compared to those with the lowest blood lead levels.[19]

It is not clear why race modifies the association between blood lead and blood pressure and odds of hypertension in population-representative data. Several new studies suggest that nutrition and stress enhance vulnerability to the hypertensive effects of lead. In a 2007 study, researchers examined the role of perceptions of stress in the association between bone lead and the risk of developing later hypertension in men. They reported that men who perceived a high level of stress in their lives have more than double the risk of developing lead-related hypertension compared to men who perceived low levels of stress.[9] Results are similar when other measures of stress are used.[10] Although not yet examined in black populations, these results taken together suggest that, even at current low levels of blood lead and low disparities, the widely documented racial disparities in such factors as stress can result in disparities in lead-related morbidity and mortality.[31,32]

The synthesis of the literature indicates that both social and environmental factors contribute to the racial disparities in hypertension. Even at low levels of blood lead, blacks—but not whites—show an effect on blood pressure and hypertension, suggesting that social factors may amplify the deleterious effects of lead. Hypertension disparities are important not only for health: if blacks had the lower hypertension rates of whites, nearly \$2.8 billion would be saved annually in health care costs.[13] This information challenges researchers and policy makers to rethink approaches to racial health disparities, as these disparities result from complex pathways interconnecting social and environmental factors.

Research And Policy Recommendations

A Fundamental Shift

We call for a fundamental shift in the approach to racial health disparities based on a cumulative risk/impact framework. This framework accounts for the simultaneous and cumulative consideration of social and environmental health risks that burden socially disadvantaged communities, including black communities, as they experience a double or even triple threat with regard to environmental health.

On the one hand, these communities experience more frequent exposure to multiple environmental hazards over their lifespan compared to more advantaged communities. These communities are more likely to experience greater exposure to lead with simultaneous exposure to other environmental hazards such as hazardous waste, air pollution, and noise pollution.

On the other hand, socially disadvantaged communities also experience greater levels of exposure to multiple factors that increase vulnerability to the health effects of environmental hazards. In other words, they are more likely to experience high stress, along with other social and economic factors that may increase vulnerability.[3,4,33]

In 2004, notions of cumulative risk/impact moved into broader environmental health discussions when the EPA's National Environmental Justice Advisory Council published a report outlining the details of a cumulative risk/impact framework. For the first time in the agency's history, notions of social factors as sources of increased vulnerability to environmental hazards were brought into the understanding of risk assessment.[12]

Adopting this framework necessitates a shift toward an interdisciplinary approach to the study and elimination of racial health disparities.[3,4,33] The science of health disparities not only includes the social, behavioral, biological, and environmental determinants, but it lies at their intersection. Although many disciplines have incorporated measures of other disciplines, such as racial categories in biomedical research, the lack of understanding of those measures between disciplines has resulted in limited or inappropriate interpretation of results. Health disparities research is better accomplished when we have an integrated understanding of racial disparities in environmental exposures and social factors, the meaning of US racial categories, and biological mechanisms.

Similarly, we call for an interagency approach to the elimination of health disparities. Recently, the EPA outlined a cross-agency plan to guide the integration of environmental justice, or the equitable distribution of environmental hazards, into environmental policy. [34] This "Plan EJ (for Environmental Justice) 2014" contains several components in both policy and research, and different offices within the agency are leading different components. In this cross-agency manner, the EPA is approaching environmental health disparities with the understanding that, in order to eliminate health disparities, collaboration is necessary.

We believe that Plan EJ 2014 serves as an example of what can be implemented within agencies and we recommend it as a blueprint for other agencies.

Disparities In Body Burden

Black Americans are more likely live in close proximity to sources of hazardous substances compared to white Americans.[5,21,35] One way to address these exposure disparities is to prioritize environmental justice in permitting policies, which are policies that direct the location of hazardous waste sites. Decisions on the placement of hazardous materials must consider not only the current hazard burden on a community, but also social and economic burdens and other health risks.

Tools have been developed to measure this cumulative impact of multiple environmental, social, and health risks within communities.[36-38] For example, researchers in California are developing an air pollution screening tool that results in a "cumulative impact" score for communities. The score is the total points accrued based on environmental factors such as proximity to hazardous sources and social factors such as the poverty rate.[38] Tools like this can be used to guide decision makers in the location of hazardous materials away from

communities burdened with high levels of environmental hazards and social factors that increase vulnerability to the health effects of these hazards.

We also recommend improved markers of environmental exposure, specifically markers of body burden.[37] Regarding lead, measures are generally obtained from blood. However, blood lead markers estimate recent exposures to lead—and this exposure may be from either external sources or from internal bone lead stores. Researchers have developed a noninvasive marker of cumulative lead burden in bone, using x-ray technology adapted for measuring lead that is suitable for population studies and clinical measurements.[22] Notably, research suggests that adults are unaware of exposure to lead, highlighting the need to use a cumulative exposure biomarker.[7]

However, this measurement method may not be feasible in some settings because of cost. Therefore, researchers have developed an approach to predict bone lead levels using blood lead levels and other social, behavioral, and biochemical factors.[39] A bone lead prediction algorithm is derived in the sample that contains both bone and blood lead. Then this algorithm can be applied to any survey that includes blood but not bone lead information to get the predicted bone lead levels. To date, the prediction algorithm has been developed in a sample of older white men and is best generalized to similar populations. To develop bone lead prediction algorithms for other groups, we recommend measuring bone lead levels in a large-scale, population-representative survey that includes adequate numbers of black (and other nonwhite) men and women across a large age range such as the National Health and Nutrition Examination Survey, administered by the Centers for Disease Control and Prevention, which is the survey that also tracks national blood lead levels for the US. The bone lead prediction algorithm derived from blood lead levels and other factors in this survey can then be applied to other surveys that include blood lead but not bone lead information.

No safe level of lead has been determined.[21] Yet, occupational guidelines have not been adequately updated since they were originally established in 1973 by the Occupational Safety and Health Administration.[40] These guidelines require that people be removed from the work environment when blood lead levels reach 50 or 60 micrograms per deciliter; they may return to work when blood lead levels reach 40 micrograms per deciliter.[40,41] These guidelines were developed decades ago, with a focus on the acute effects of lead poisoning. Current research consistently demonstrates numerous deleterious chronic health effects -- ranging from cognitive decline to reproductive problems to hypertension -- at substantially lower blood lead levels.[42-44] We recommend updating these guidelines to reflect the current research on lead and health.

Finally, we also recommend research into treatment for the health effects of environmental exposures. For example, because lead mimics calcium in the body, calcium-channel blockers may be more effective in reducing blood pressure compared to other anti-hypertensive medication.[45,46] Efforts to educate health care providers about the environmental risk factors associated with hypertension may facilitate more effective medication selection.

Integrate Health Into Social Policy

Disparities in social stressors are thought to contribute to racial health disparities through the enhanced vulnerability to environmental hazards.[3] Researchers developed a model outlining the pathways through which stress could alter vulnerability to the health effects of environmental hazards and result in health disparities.[3] In their model, community and individual stress, resulting from neighborhood resources, community stressors, and other

structural factors affect environmental health disparities at multiple points in the pathway from environmental exposure to health effects.

This growing area of research challenges policy makers to address racial disparities in exposure to social stressors, including poverty, unemployment, and violence, in efforts to eliminate racial disparities in environmental health. We continue to urge policy makers to view social and economic policy as health policy. One important way to integrate these traditionally separate policies is the inclusion of health in cost-benefit analyses.[47] In this way, health becomes integrated into the larger discussion of areas such as education, criminal justice, and the labor market.

Conclusion

As mentioned above, one of the four overarching goals of the Healthy People 2020 initiative is to “achieve health equity, eliminate disparities, and improve the health of all groups.”[1] Our synthesis of the literature indicates that social and environmental factors interact to result in racial health disparities. The first step to meet the goals set forth in Healthy People 2020 is a fundamental ideological shift, based on the cumulative risk/impact framework, with the understanding that social, economic, and environmental policy is health policy. To ensure the permanent adoption of this approach, we urge agencies and research institutions to develop a strategic plan for the institutionalization of key components of the framework, such as interagency and interdisciplinary collaboration and the integration of social and environmental factors in health policy and research.

Within this new approach, development and testing of tools to measure environmental exposure body burden and cumulative social and environmental risk are needed. More evidence on stress and vulnerability in socially disadvantaged communities is also needed, as much of the work is still in the theoretical stage. Timely application of evidence to policy is also warranted, such as updating the lead action levels for occupational exposures. Finally, health needs to be included in cost-benefit analyses of social and economic policies.

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