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Quantifying the invisible: A literature review and history of research on the health effects of wildfire smoke

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INTRODUCTION: The objective of this scoping review is to provide an overview of issues affecting the results of studies on the health effects of non-occupational wildfire exposure. Although it is well established that wildfire smoke is harmful to people with chronic respiratory conditions, research on other health impacts has often found inconsistent results or small effect sizes. These results are often misinterpreted to mean that wildfire smoke has a negligible effect on non-respiratory outcomes such as cardiovascular health or mortality. However, what these results actually reflect is the complexity of determining public exposure to wildfire smoke, as well as variations in how researchers have chosen to address the issues raised by these complexities.

RESULTS: 3 central issues were found in the literature:

1. Lack of statistical power

Finding: Periods of heavy wildfire smoke, also called smoke waves, tend to be brief. This makes it difficult for studies to achieve enough statistical power to identify many health outcomes.

Example: In “Wildfire air pollution and daily mortality in a large urban area,”1 the researchers found no effect on mortality. However, Hanninen pointed out that the short duration of the smoke wave examined in the research led to a lack of statistical power. With only two days of data, the study could not have “produced a positive finding, and the expected negative finding should therefore not be considered as evidence of lack of mortality risk from smoke particles.”2

2. Lag time between exposure and outcomes varies

Finding: Studies do not always account for the fact that lag times differ between health outcomes. Respiratory symptoms appear on the same day the smoke does; other outcomes appear later.

Example: A 2017 study published in Epidemiology found that “smoke waves were not associated with increased rates of cardiovascular hospital admissions.”3 However, my review identified that the study probably did not find an association because researchers looked on the wrong day; the day the smoke wave began (i.e., lag 0), rather than two days into the smoke wave (i.e., lag 2), when cardiovascular hospital admissions are more likely to appear.4

3. Technical limitations of air quality monitors

Finding: Fine (PM$_{2.5}$) and ultrafine particulate matter (PM$_{1}$), which are more harmful to health than larger course particles (PM$_{10}$), can only be detected with newer, more sophisticated air quality monitors.

Example: A review by Liu et al. notes that “PM$_{10}$ was the most commonly studied pollutant for cardiovascular diseases and most of the PM$_{10}$-cardiovascular studies (8/9) did not find any significant association.”5 However, a review by the American Heart Association noted that PM$_{2.5}$ is “more harmful to the cardiovascular system than larger course particles,” and that “elevated mortality risks were most strongly associated with PM2.5. Coarse particles... were generally not significantly related to mortality.”6

METHODS: A PubMed search was carried out using these terms: ‘health,’ and ‘wildfire,’ ‘wildlands fire,’ or ‘biomass smoke.’ A snowball technique was used to collect additional articles from reference lists. Articles not in English or focused primarily on the psychological effects of wildfire were excluded.

NEXT STEPS: Acknowledging the problems in measuring the health effects of wildfire smoke allows the public and the medical community to put research results into context and avoid drawing false conclusions. Advances in air quality monitoring, smoke modelling, and improvements in the quality of electronic health record data all have the potential to provide more precise results in the future.

2. Hanninen O. Challenges in estimating the health effects of biomass smoke—my review identified that the study probably did not find an association because researchers looked on the wrong day; the day the smoke wave began (i.e., lag 0), rather than two days into the smoke wave (i.e., lag 2), when cardiovascular hospital admissions are more likely to appear.4