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Synopsis: Living near or migrating to areas at high risk for wildfires may result in health consequences and increased disparities for pregnant people and their children.

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Introduction

The amount, frequency, and duration of wildfires are increasing worldwide [1]. Along with the increase in wildfires comes an increase in wildfire smoke exposure and concern for its association with adverse health effects [2]. Maternal exposure to wildfire smoke has been linked to birth outcomes such as reduced birth weight and preterm birth [3].

In this article, we focus on California, USA where up to 4% of preterm births have been attributed to wildfire smoke exposure during pregnancy [4]. We discuss how a housing shortfall in urban areas has led to large scale migration to wildfire- and smoke-prone areas as well as the implication for future perinatal health disparities in California. To ensure that adverse perinatal outcomes do not fall disproportionately on populations moving to inland areas, we argue the need to consider the role of housing policies in shaping migration patterns and potential downstream health disparities. In particular, we recommend new housing, densification, and upzoning (*i.e.*, change zoning codes to allow development) of urban core areas and offset growth in climate and wildfire prone parts of California.

Smoke Exposure During Pregnancy

Adverse birth outcomes including preterm birth and low birth weight are important risk factors for perinatal mortality and adverse health consequences in childhood and adulthood. Pregnant persons and their unborn fetuses are particularly vulnerable to air pollution exposure owing to physiological changes during pregnancy including increased respiratory rate and cardiac output, and rapid growth and development of the fetus [5]. Pregnancy is a critical period and previous studies have found consistent associations between air pollution and adverse birth outcomes [6]. Black women and women residing in neighborhoods with low socioeconomic status may be more vulnerable to wildfire smoke exposure and adverse birth outcomes as stronger associations between air pollution and preterm birth have been seen in these subgroups [7,8].

It is hypothesized that wildfire smoke may be even more harmful than other types of air pollution given the increased levels of particulates and its constituents [9]. The effects of wildfire smoke may have resulted in as many as 7,000 extra preterm births in California between 2007 and 2012 [4]. This number may increase given the state's largest wildfires have occurred more recently [10].

In California, an ongoing housing deficit for the past 50 years in urban cores such as Los Angeles and San Francisco has resulted in extreme unaffordability of coastal urban areas, and migration to inland areas where housing is relatively cheaper. In coastal urban areas, there is also a growing mismatch between housing costs and income earnings. In the past two decades, home values have risen at a much faster rate than median household incomes. The recent growth in high paying jobs in the high-tech industry in coastal areas has increased average incomes and average home prices while incomes of many other occupations have not kept up with the rising housing prices. This discrepancy between home prices and income combined with a shortage of overall housing production has led to the housing affordability crisis which has driven migration to inland areas [11]. These inland areas that are growing in population are often in the wildland-urban interface (WUI), that is, the zone of transition between wilderness and developed land. Due to climate change are becoming at higher risk of burning [12,13]. Although the Sierra Nevada mountain range and the northern parts of the state have been the major areas consumed by wildfires in the past few years, fire risk in other parts of the state is rapidly growing as temperatures increase. Six of ten of the state's fastest growing counties are in the Central Valley and Inland Empire, regions that are at very high risk of extreme heat [12].

The migration patterns from coastal cities to inland areas reveal socioeconomic, racial, and ethnic disparities. Of those who are leaving urban cores, high-income migrants are more likely to move between

other coastal Californian cities or out-of-state metro areas. On the other hand, low-income migrants are overrepresented among those who are moving from costal urban areas to more affordable parts of inland California. In a study done of migration patterns between 2010 and 2016, over 55% of those leaving the Bay area who earned less than $50,000 a year stayed in the state. In the same study, one third of the households earning more than 200,000 a year moved to other high-cost regions in the state, on the coast. There are also racial disparities that characterize these migration patterns. Hispanics and Blacks represent a disproportionate proportion of the low-income migrants moving from the urban cores to more affordable parts of California—50% of Hispanics and 36% of Blacks moving out of the urban core left for more affordable inland areas in California [14].

Inland areas such as the San Joaquin Valley already suffer from disproportionately high rates of air pollution and air pollution related adverse birth outcomes [15]. Prior to the recent increase in wildfires, this region has been noncompliant with the standards set by the Environmental Protection Agency for more than 25 years. Sources of air pollution include population growth, transportation corridors, agriculture productions, and warehouse distribution. In addition to sources, poor horizontal dispersion due to surrounding ranges trap air pollutants in the valley. This is exacerbated in the winter due to meteorologic inversions limiting vertical dispersion and trapping pollution closer to the ground [16]. Anticipated increases in temperatures and wildfires in these areas are expected to exacerbate these existing perinatal health disparities.

Need for improved housing policy to address risks for pregnant mothers in California

The housing deficit and affordability crisis in urban areas is driven largely by exclusionary housing policies that limit densification and new housing development. Driven by the state's rapid population growth, the demand for housing far exceeds the housing that is being built in coastal areas. Forces such as community opposition from existing home-owners ("Nimbyism"), environmental regulations (California Environmental Quality Act) and limited land has stifled the growth of new housing developments. As land is expensive in coastal metro areas, densifying each plot could help make individual units more affordable. However, zoning reform has lagged and such measures have not taken place. Collectively, these policies have created the housing shortages and unaffordability in coastal areas that have driven the growth of new communities in inland areas [17].

The rapid population growth in inland areas with high fire risks, as well as the disproportionate share of low-income Black and Hispanic people that are migrating to these areas and experiencing the downstream health effects of living in those areas must be addressed. Housing policy reform is needed to enable those who want to live in coastal metro areas the opportunity of affordable housing. Such policies would have the added benefit of keeping working populations close to job centers and reducing climate change effects of commuting and traffic-related air pollution. Some solutions could include the creation of more infill housing units (*i.e.*, new housing built in existing neighborhoods) in urban areas around existing housing developments; however, they also need to be accompanied by sustainable communities practices such as affordable housing for extremely low and very low income residents, climate resilient housing, and investment in infrastructure and services in surrounding areas [18].

Conclusion

Living near or migrating to areas that are at high risk for wildfires is a problem resulting in health consequences for pregnant people and their children. Although California serves as an example, this is a global problem with an increasing number of countries experiencing major wildland fire losses [19]. Housing, land use, and development policies need be designed to ensure housing equity in more fire- and climate-resilient areas. This includes prioritizing development and densification of existing urban areas

and deprioritizing development of urban sprawl that is near the WUI or subject to extreme temperature increases. These policies can help protect public health and contribute to housing and health equity.

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Conflict of Interest
The authors report no conflicts of interest.

Author Contributions
RSS designed and drafted the commentary; RSS and AMP contributed to the writing and revising of the commentary.

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