



Health, Wildfires & Climate Change in California

Recommendations for Action

October 2019

Published at UC Berkeley by:
The CITRIS Policy Lab, CITRIS and the Banatao Institute
California Institute for Energy and Environment



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Executive Summary

Overview

This white paper makes recommendations for action to reduce the serious health impacts of wildfires in California's increasingly hot climate. The recommendations include new or expanded programs, funding streams, regulations, and research. The recommendations were developed by academics and practitioners at a UC Berkeley workshop in Spring 2019, a statewide webinar in July 2019, and through interviews with selected health/wildfire stakeholders.

Wildfires in California

The wildfire problem in California is growing in a hotter climate. Fifteen of the twenty largest fires in California history have occurred since 2000. The largest, most destructive and deadliest fires in California history have all occurred in the last 2 years. Fire season is getting longer and fire behavior is changing. New research projects that California's rainy season will become increasingly concentrated in the winter months between December and February while April, May, September, October, and November will become increasingly dry, meaning that the state's wildfire season will start earlier and end later.

Wildfires and Human Health

Climate change is a global health emergency. The impacts of a rapidly changing climate are now seen as potentially catastrophic for human survival. The impacts of heat, drought, sea level rise, extreme storms, and wildfires threaten to undermine the last half-century of gains in development and global health. Recent global and national reports have concluded:

- Climate change is impacting our health now
- The warmer it gets, the worse it will get
- We need to adapt at the same time as we are working to reduce emissions
- Failure to take transformative action with great urgency risks catastrophic effects on human health and well-being
- There are greater health risks for children, older adults, low-income communities, and communities of color
- "A health-in-all-policies" approach is required

The increase in California wildfires is a growing problem for human health. Residents and workers who are directly impacted by wildfires can suffer loss of life as well as major injuries such as burns and broken bones. Residents and workers in fire areas and those who live at some distance can be significantly harmed by air pollution from wildfires, particularly PM 2.5. When wildfires burn into urban areas, buildings and vehicles burn, producing smoke that can contain a number of toxic air contaminants.

There is clear evidence of an association between wildfire smoke and respiratory health, including

asthma, chronic obstructive pulmonary disease (COPD) and respiratory infections. Wildfire PM2.5 is associated with heart attacks and strokes for all adults, particularly for those over 65 years old. Other health outcomes from wildfire smoke events include adverse birth outcomes, mental health issues, child neurodevelopment and the health of pregnant mothers. Wildfires have been demonstrated to produce a number of negative health effects for fire fighters, including degraded lung function. PM2.5 from wildfire smoke can have a significant impact on health of outdoor workers.

Recommendations for Action in California

..... **A. NEAR-TERM SOLUTIONS FOR REDUCING HEALTH IMPACTS FOR RESIDENTS IN HIGH-RISK FIRE AREAS (COULD BE IMPLEMENTED IN THE NEXT 1-3 YEARS).**

- A1. Create community outreach, education and communications programs, tailored to specific communities, on health impacts from wildfires.
- A2. Widely implement technology solutions (new and existing) to improve fire/smoke monitoring, communications, evacuations, and other health/fire activities.
- A3. Build community capital to create stronger, more resilient communities before fires occur (and prepare communities for a range of climate impacts).
- A4. Improve and expand strategies for health protection during fire events, e.g., evacuation routes and procedures, shelter in place, and other life saving strategies.
- A5. Integrate government agencies and programs to bring substantial funding to state and local efforts for infrastructure hardening.

..... **B. LONGER-TERM SOLUTIONS FOR REDUCING HEALTH IMPACTS FOR RESIDENTS IN HIGH-RISK FIRE AREAS (COULD BE IMPLEMENTED IN 3+ YEARS)**

- B1. Develop a culture change in California among the general public to support a shift in forest management practices that will increase forest resilience and health.
- B2. Accelerate the pace and scale of statewide forest & vegetation management—thinning, prescribed/natural burns, etc.
- B3. Align financial solutions—insurance, bonds, development fees, etc. — to reduce risk in high fire hazard areas and to fund actions such as retrofitting homes.
- B4. Reform land use regulations to restrict, reduce or prohibit development in fire-prone areas.
- B5. Build adaptive capacity in communities in high-risk fire areas.
- B6. Accelerate California action to substantially reduce greenhouse gas emissions — adaptation and resilience activities must be conducted in parallel with carbon pollution reduction

..... **C. SOLUTIONS TO PROTECT WORKERS FROM ADVERSE HEALTH IMPACTS DURING AND AFTER FIRES**

- C1. Prevent Harm: Take action, where appropriate, to reduce fire frequency, intensity, and duration, AND protect workers during all activities—including forest management, fire management (where appropriate), fire alert activities, and energy shut-downs.
- C2. Reduce Harm: Protect and reduce exposure of workers during fire events, smoke events and in post-fire activities through respiratory protection, rotating workers out, clean-air basecamps and avoiding/reducing outdoor work.
- C3. Manage & Treat Harmed Workers: Help workers recover from health impacts during and after fires—including treating symptoms, medical monitoring, no-return policies, and long-term health care.

..... **D. SOLUTIONS TO REDUCE HEALTH IMPACTS FROM SMOKE AND ASH OUTSIDE IMMEDIATE FIRE AREAS**

- D1. Create a Health/Smoke Coordinated Game Plan (more than disconnected programs).
- D2. Develop equitable intervention solutions for different populations and environments with different degrees of smoke/ash risk. Smoke solutions for all, but with a special focus on access to solutions for vulnerable populations and communities.
- D3. Fund the development of low-cost technologies—sensors, masks, DIY filtration systems, etc.—that can be widely deployed.
- D4. Develop and implement a Coordinated Communications Strategy. Establish clear and consistent messaging and guidance that is timely and tailored to different groups (public, private entities, individuals, etc.).
- D5. Manage fires with a health lens. Deploy fire management strategies that reduce air quality impacts (in addition to reducing risks in a wildlife urban interface (WUI)).

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01 //

INTRODUCTION

This white paper makes recommendations for action to reduce the serious health impacts of wildfires in California's increasingly hot climate. The recommended actions include new or expanded programs, funding streams, regulations, and research that will provide near- and long-term health protection for Californians, with a focus on the most vulnerable populations and communities.

The recommendations were developed by academics and practitioners from a wide range of fields at a UC Berkeley workshop in Spring 2019, supplemented by a statewide webinar and individual interviews with selected health/wildfire stakeholders. For a complete list of participants see Appendix A.



FIRE DANGER
TODAY IS...
EXTREME

02 //

THE CALIFORNIA WILDFIRE PROBLEM IS GROWING

- 15 of the 20 largest fires in California history have occurred since 2000.¹
- The Sonoma-Napa fires of 2017 were the most destructive in California history (\$9 billion in damages) and deadliest (44 deaths) until the 2018 the Camp Fire (\$16.5 billion, 85 deaths). The Thomas Fire of 2017 in Southern California was the largest fire in California history (259,000 acres) until the 2018 Mendocino Complex fire (481,000 acres).² The \$16.5 billion in damage caused by the Camp Fire that destroyed Paradise was worse than the year's most damaging U.S. hurricane.³
- The average fire season in the western U.S. is now 2 ½ months longer than in the early 1970's and fire behavior is changing in the hotter and drier conditions.⁴

"We know fire behavior has changed and continues to change, yet we continue to be surprised every time, when we shouldn't be. The notion that firefighters will be able to put out, suppress or make safe a wildfire is becoming less and less of a reliable notion." – Don Whittemore, Colorado fire behavior expert.⁵

"The bushes, the trees have absolutely no moisture in them, and the humidities are so low that we are seeing these 'fire starts' just erupt into conflagrations. The fires are spreading faster than I have seen in my 30 years," – Mark Ghilarducci, Director, Governor's Office of Emergency Services, after the 2015 Butte Fire.⁶

- Research by Tony Westerling (UC Merced) shows that in the western U.S. for the last 3-4 decades, years with higher spring/summer temperatures have greater numbers of large wildfires.⁷

- Research by UC Berkeley's Patrick Gonzalez and John Battles shows that California's forests, which have sequestered important amounts of carbon for centuries, became net emitters of CO₂ between 2000-10 due to large wildfires. Conditions worsened even more after the period studied as 200 million Sierra trees were killed 2010-17 by fire, bark beetles and drought.⁸
- A 2018 paper in Nature Climate Change, led by UCLA's Daniel Swain, found that as a result of global warming, California's rainy season will become increasingly concentrated in the winter months between December and February. April, May, September, October, and November will become increasingly dry, meaning that the state's wildfire season will start earlier and end later.⁹

After the 2018 fires, Swain tweeted: *"If Northern California had received anywhere near the typical amount of autumn precipitation this year (around 4-5 in. of rain near #CampFire point of origin), explosive fire behavior & stunning tragedy in #Paradise would almost certainly not have occurred."*¹⁰

- 2018 research by UC Merced's Leroy Westerling shows that under a high emissions scenario, California will see a 75% increase in annual acreage burned by the end of the century. Extreme wildfires (larger than 24,000 acres) would occur 50% more frequently.¹¹



03 //

THE INCREASE IN CALIFORNIA'S WILDFIRES IS A MAJOR PROBLEM FOR HUMAN HEALTH

At the UC Berkeley workshop on April 30, 2019, Dr. Linda Rudolph (Center for Climate Change & Health, Public Health Institute) and Dr. John Balmes (UC Berkeley) made presentations on public health, wildfires and climate change. The summary below is based on their presentations.

Climate Change and Health

Climate change is a global health emergency. The impacts of a rapidly changing climate are now seen as potentially catastrophic for human survival. The impacts of heat, drought, sea level rise, extreme storms, and wildfires threaten to undermine the last half-century of gains in development and global health. In the last year, a series of global and national organizations have produced in-depth reports focused on health and climate change, including:

- 2018 Lancet Countdown: Tracking Progress on Health and Climate Change¹²
- 4th National Climate Assessment: Chapter 14: Human Health¹³
- World Health Organization (WHO) COP24 Special Report: Health and Climate Change¹⁴

Overall, what did these reports tell us?

- Climate change is impacting our health now.
- The warmer it gets, the worse it will get.

- We need to adapt at the same time as we are working to reduce emissions.
- Failure to take transformative action with great urgency risks catastrophic effects on human health and well-being, and possibly on survival of human civilization.
- While climate change will eventually affect all people, there are greater health risks for children, older adults, low-income communities, and communities of color.
- “A health-in-all-policies” approach is required, in which the health implications of decisions in all public policies are accounted for, synergies are promoted and negative health outcomes avoided, in a transparent and accountable process.

Wildfires and Health

Residents and workers who are directly impacted by wildfires can suffer from serious health-related issues, including:

- Loss of life
- Burns, broken bones and other major injuries
- Loss of homes and businesses
- Post-Traumatic Stress Syndrome (PTSD)
- Mental health issues from job loss, community loss, etc.

Residents and workers in fire areas and those who live at some distance can be significantly harmed by air pollution from wildfires:

- Particulate Matter
- Carbon Monoxide
- Nitrogen Oxides
- Polycyclic Aromatic Hydrocarbons
- Volatile Organic Compounds
- Ozone

When wildfires burn into urban areas, buildings and vehicles burn, producing smoke that can contain a number of toxic air contaminants:

- Hydrogen Cyanide
- Hydrogen Chloride
- Phosgene
- Metals
- Toluene
- Styrene
- Dioxins

The 2018 Camp Fire in Paradise sent air quality index readings soaring near the fire area and much above normal levels more than 150 miles away in the Bay Area. The air quality index (AQI) (combined PM and O₃) was over 400 near the fire in Yuba City, 300 in Sacramento and 200 in the Bay Area.

There is clear evidence of an association between wildfire smoke and respiratory health.

- Asthma exacerbations are significantly associated with higher wildfire smoke in nearly every study.
- Exacerbations of chronic obstructive pulmonary disease (COPD) are significantly associated with higher wildfire smoke in most studies.
- There is growing evidence of a link between wildfire smoke and respiratory infections such as pneumonia and bronchitis.

Wildfire PM_{2.5} is associated with heart attacks and strokes for all adults, particularly for those over 65 years old. Increase in risk the day after PM_{2.5} exposure is as follows:

- All cardiovascular, 12%
- Heart attack, 42%
- Heart failure, 16%
- Stroke, 22%
- All respiratory causes, 18%
- Abnormal heart rhythm, 24% (on the same day as exposure)

Other health outcomes from wildfire smoke events include:

- Adverse birth outcomes
- Mental health issues
- Cognitive decline
- Child neurodevelopment
- Health of pregnant mothers

Wildfires have been demonstrated to produce negative health effects for fire fighters:

- Cross-shift changes in lung function, urinary biomarkers of exposure, and blood biomarkers of inflammation
- Pre-post season changes in lung function, airway responsiveness, and airway inflammation

PM_{2.5} from wildfire smoke can have a significant impact on health of outdoor workers—construction, agriculture, recreation, delivery, tourism, etc.—as well as those who work in semi-outdoor environments like auto repair shops.



04 //

RECOMMENDATIONS FOR ACTION IN CALIFORNIA

The recommendations for action are divided into four categories, based on target populations:

- A. Near-term solutions for reducing health impacts for residents in high-risk fire areas (could be implemented in the next 1-3 years).
- B. Longer-term solutions for reducing health impacts for residents in high-risk fire areas (could be implemented in 3+ years).
- C. Solutions to protect, treat and support workers for fire and smoke events—first responders, medical personnel, clean-up laborers, outdoor workers, etc..
- D. Solutions for reducing health impacts of smoke and ash for people living outside the immediate fire areas.

Each working group at the April 30th workshop was asked to propose five key solutions for their target population. The subsequent webinar, phone interviews and email exchanges worked to fill gaps, strengthen language, and add emphasis for each group's 5 proposed solutions.

..... **A. NEAR-TERM SOLUTIONS FOR REDUCING HEALTH IMPACTS FOR RESIDENTS IN HIGH-RISK FIRE AREAS (COULD BE IMPLEMENTED IN THE NEXT 1-3 YEARS).**

A1. Create community outreach, education and communications programs, tailored to specific communities, on health impacts from wildfires.

- a. Provide substantial funding for local governments and community partners and to systematically identify and map individuals and groups who are most vulnerable to fire impacts.
- b. To design and conduct outreach, partner with Promotores de Salud, the California Association of Community Health Workers, environmental justice organizations, immigrant community or-

- ganizations and other groups who are already working with highly vulnerable populations.
- c. Ensure that both pre-fire education/outreach and emergency communications during fire events effectively reach ALL populations.
 - d. Align and integrate communications on fires/health with messaging about preparing for heat, drought, extreme storms and other climate impacts (don't create more silos).

Research needed to support Solution A1:

- Identify best practices, lessons learned, etc. from existing community outreach programs for heatwaves, earthquakes and other events.

A2. Widely implement technology solutions (new and existing) to improve fire/smoke monitoring, communications, evacuations, and other health/fire activities.

- a. Develop a statewide “Clearinghouse” of effective technology solutions that are available, in-development and in the concept stage.
- b. Develop tech strategies that take into account the ‘digital divide’ for vulnerable populations and communities, especially for elderly or rural populations.
- c. Manage power utility shut-offs in high fire-risk areas to minimize adverse health impacts on individuals who must have power for mobility, health aids, AC, etc.
- d. Develop sufficient back-up generation to provide days/weeks of energy for critical resources—hospitals, community centers, etc.—and sensitive facilities such as senior living centers during power shut-off events.
- e. Develop information technology solutions to support fast, effective evacuations.
- f. Develop better decision-making tools/simulation models for officials to plan for and make decisions about (in real-time) evacuation/warning info dissemination.

Research needed to support Solution A2:

- Analyze ‘core technologies’ available and proposed. Which are cost-effective, easily deployed, etc.?
- Which languages are needed for alert and warning systems in various communities? What are the key gaps in communications systems?
- Develop a better understanding about vulnerable populations’ access to tech solutions
- What information is needed by the public (including vulnerable populations) before, during and after a WUI fire event; including the best ways to send information to households (and the role maps can play)?
- How to make use of ‘smart buildings’ or other smart technologies for communicating with the public.
- Which energy technologies are most resilient to fire impacts and therefore most helpful to building community resiliency?

A3. Build community capital to create stronger, more resilient communities before fires occur (and prepare communities for a range of climate impacts).

- a. Provide financial support to programs that increase community and neighborhood cohesion so communities can do more to help themselves during and after fires.

- b. Partner with and financially support Frontline CBO's.
- c. Expand Community Emergency Response Teams (CERT) and secure funding to expand the program statewide.
- d. Organize communities by building on existing networks such as in-home care providers, PTAs, neighborhood councils, etc.
- e. Create and fund a major state and local campaign on defensible space and other community-based fire preparation strategies.

Research needed to support Solution A3:

- Evaluate the effectiveness of existing programs in California to build stronger, more resilient communities.

A4. Improve and expand strategies for health protection during fire events, e.g., evacuation routes and procedures, shelter in place, and other life saving strategies.

- a. Work with communities to develop and publicize evacuation routes that are clear and accessible to ALL populations and hold practice exercises.
- b. Partner with groups who work with individuals that have restricted mobility—in-home care providers, child care providers, skilled nursing facilities, etc.— to develop transportation plans for evacuations of people without cars or that are unable to drive.

Research needed to support Solution A4:

- Perform behavioral studies of Wildland Urban Interface (WUI) community populations to better understand members' needs and intentions associated with evacuation.
 - What factors influence wayfinding behavior before/during wildfires – i.e., familiarity, road/route characteristics, congestion, direction/instructions provided, etc.?
 - What factors influence household decision-making to evacuate, including the types of actions people perform before and during evacuation?
 - What are the common “trigger points” set by emergency officials to warn/evacuate populations for wildfires and the methods for setting these trigger points?

A5. Integrate government agencies and programs to bring substantial funding to state and local efforts for infrastructure hardening

- a. Rewrite building codes to upgrade and retrofit buildings in high-risk fire areas (Universal Building Codes).
- b. Harden hospitals and clinics for fire and smoke impacts so fewer patients will have to be evacuated.
- c. Harden and rebuild with low/no toxic materials so future fires produce less toxic smoke, clean-up, etc.

Research needed to support Solution A5:

- Review and study “success stories” for building code revisions (e.g. post-Paradise example).

..... **B. LONGER-TERM SOLUTIONS FOR REDUCING HEALTH IMPACTS FOR RESIDENTS IN HIGH-RISK FIRE AREAS (COULD BE IMPLEMENTED IN 3+ YEARS)**

B1. Develop a culture change in California among the general public to support a shift in forest management practices that will increase forest resilience and health.

- a. Design and conduct an educational program about how/why changes in forest management are needed for forest health and public health.

B2. Accelerate the pace and scale of statewide forest & vegetation management—thinning, prescribed/natural burns, etc.

- a. Substantially increase funding for this work to implement long-term, on-going forest management at the landscape scale across California.
- b. Review CEQA and other regulatory processes to identify their positive and negative impacts on forest management practices.
- c. Develop a multi-benefit approach to forest and vegetation management. For example, develop wood products and markets that prioritize carbon storage and durable utilizations.
- d. Partner with rural residents and tribal communities who live in areas that need more effective forest management.
- e. Develop a job pathway for prison inmates who work on fires to get training and forest management jobs when they are released.

Research needed to support Solution B2:

- More research on the health impacts of the hotter and larger fires that we are experiencing.
- Develop better understanding of the health impacts of prescribed burns vs. major wildfires, including chronic and acute effects.
- Create a more reliable mapping of forest inventory.
- Develop better and more detailed fire risk maps to focus forest management efforts in the next 3-5 years (can't do it all everywhere immediately).
- Create a better understanding of carbon storage long-term for prescribed burns vs. catastrophic wildfire.

B3. Align financial solutions—insurance, bonds, development fees, etc.—to reduce risk in high fire hazard areas and to fund actions such as retrofitting homes to combat fires.

- a. Accurately price risk of development in Wildland Urban Interface (WUI).
- b. Secure funding to support development and land use goals that reduce fire risk.
- c. Focus on the power of insurance.
- d. Design financial programs to benefit vulnerable communities such as renters.

Research needed to support Solution B3:

- Conduct research into the ways that financial solutions can help and not hurt low-income residents.

B4. Reform land use regulations to restrict, reduce or prohibit development in fire-prone areas.

- a. Create a State/Local Blue Ribbon Commission to study and make recommendations on this critical, but charged issue.
- b. Develop a statewide/local plan for managed retreat where appropriate in high-risk areas.
- c. Provide financial incentives to discourage rebuilding in high risk fire areas.
- d. Develop and implement improved building codes and landscaping codes for both new and rebuilt structures and properties.
- e. Ensure that displaced renters, not just displaced homeowners, are protected and supported in post-fire recovery.
- f. Consider relocating communities, not just individuals, that are in high-risk fire areas.

Research needed to support Solution B4:

- Create reliable mapping of development and fuel loads so we can better understand our situation and make better decisions.
- Develop improvements in building and landscaping standards for use in fire-prone areas and the wildland/urban interface.

B5. Build adaptive capacity in communities in high-risk fire areas.

- a. Support and expand Community Fire Safe Councils (California) and learn from the Fire-Adapted Communities Network (U.S.).
- b. Fund community-based organizations to carry out self-directed programs (not just funding for government agencies) – ask them what they need.
- c. Build economic resilience in rural areas that often are already economically depressed. Address the need for economic revitalization, not just fire recovery.
- d. Implement and expand rural broadband for fast communications in emergencies and for information sharing before fire events.
- e. Plan for and address the needs of renters who will face different displacement issues than homeowners.
- f. Fund paid positions for community members to work with government agencies charged with community fire safety programs.
- g. Ensure that economic development recovery plans include and feature the needs of displaced workers provide extra support to hourly and undocumented workers.
- h. Create and expand workforce development programs for rural areas before and after fires
- i. Underground utilities in high fire risk areas.

B6. Accelerate California Action to substantially reduce greenhouse gas emissions – adaptation and resilience activities must be conducted in parallel with carbon pollution reduction

- a. Accelerate action to reduce GHGs and attain the goals of AB 32, SB 32 and California's other climate mandates.

Research needed to support Solution B6:

- Which GHG cutting/eliminating actions will have the greatest positive health impacts in California?

..... **C. SOLUTIONS TO PROTECT WORKERS FROM ADVERSE HEALTH IMPACTS DURING AND AFTER FIRES**

C1. Prevent Harm: Take action, where appropriate, to reduce fire frequency, intensity, and duration, AND protect workers during all activities—including forest management, fire management (where appropriate), fire alert activities, and energy shut-downs.

Develop improved health and safety programs for workers dealing with forest management hazards—tree falls, smoke exposure, heavy equipment operation injuries, forest thinning injuries.

- a. Contractor registry – accountability and tracking
- b. Contractor oversight by state
- c. Improved worker training
- d. Improved health and safety standards
- e. Stronger illness and injury prevention programs
- f. Training and/or regulations for laborers hired by homeowners and private forest owners
- g. More health/safety oversight for CAL FIRE employees
- h. More health/safety oversight for incarcerated firefighters
- i. Provide basic fire training for communities so they can support professional fire fighters prior to and during events

Research needed to support Solution C1:

- Expanded research on fire fighter exposure to toxics like the recent UC Berkeley research on mercury exposure during the Tubbs Fire (Rachel Morello Frosch with the San Francisco Firefighters Cancer Prevention Foundation).

C2. Reduce Harm: Protect and reduce exposure of workers during fire events, smoke events and in post-fire activities through respiratory protection, rotating workers out, clean-air basecamps and avoiding/reducing outdoor work.

To support frontline fire responders - fire fighters, EMS workers, hazmat workers, evacuation workers, law enforcement, utility workers, etc.

- a. Make California the U.S. leader in fire worker protection.
- b. Effective Respiratory protection equipment products are available —Powered Air-Purifying Respirators (PAPRs)— but we need regulations and funding to create markets and get manufacturers to scale-up production. N95 masks are not adequate. Effective respiratory protection must be lightweight, durable, reduce work of breathing, cool, long-lasting.
- c. Develop new OSHA emergency standard.
- d. Develop and deploy effective clean air trailers.

To support post-fire workers in burned areas for clean-up, salvage and re-building—laborers, construction workers, equipment operators, hazmat, utility workers, media, local government staff, etc.

- a. Post-fire conditions vary widely, but we generally know enough to take action.
- b. Develop and distribute effective respiratory protection (PAPRs). N95 probably not sufficient for workers.
- c. Develop new OSHA standards for unique hazards in this setting.
- d. Contractor standards/registry needed to monitor health issues and conduct exposure research.
- e. Assess and plan for housing and other needs immediately after fire to ensure access to affordable housing and services for all workers.
- f. Ensure fair wages/good working conditions for all workers who are participating in the recovery and rebuild.

To support outdoor workers and indoor workers in unfiltered buildings during smoke events—farm-workers, construction, transit, delivery, road work, landscapers, day laborers, utility workers, plus many types of unprotected indoor workers.

- a. Implement new Cal-OSHA emergency regulations (passed in July 2019) to cover outdoor workers and semi-indoor workers in smoke conditions. The new rules, which will be in place while permanent regulations are developed, require employers to take action when smoke from wildfires reaches 151 or greater on the Air Quality Index.
- b. AB 1124 introduced in legislature February 2019 to require protection for outdoor workers.

Research needed to support Solution C2:

- Exposure research needed for post-fire workers, particularly for laborers and others with prolonged exposure.
- Need exposure studies for outdoor workers and smoke.
- Need better understanding of the triggers for determining respiratory protection (N95s) for outdoor workers.
- Research to assess pre- and post-response efficacy of respiratory protection equipment and of biomarkers of exposure.
- Research on existing safety nets/support systems available and where there are gaps, e.g., no FEMA benefits for undocumented, no financial assistance for workers who won't expose themselves to PM 2.5 during wildfires.
- Exposure research to include skin exposure hazards and safety hazards for both response and recovery workers.
- Research towards improved design of personal protective equipment for use during response and recovery operations, including field testing under hazardous conditions.

C3. Manage & Treat Harmed Workers: Help workers recover from health impacts during and after fires—including treating symptoms, medical monitoring, no-return policies, and long-term health care.

To support frontline fire responders - fire fighters, EMS workers, evacuation workers, law enforcement, utility workers, etc.

- a. Define the population at risk. (Tens of thousands of workers).
- b. Create a registry of workers who enter fire zones—fire fighters, laborers, incarcerated, etc.—and track those who are harmed.

- c. Support community health centers to provide post-fire care.

To support post-fire workers in burned areas for clean-up, salvage and re-building—laborers, construction workers, equipment operators, hazmat, utility workers, media, local government staff, etc.

- a. Create a registry of these workers and training programs for them.
- b. Support community health centers to provide post-fire care.
- c. Create contingency plans to ensure prompt medical care is available if existing medical services are severely limited or unavailable to responders.

To support outdoor workers during smoke events—farmworkers, construction, transit, delivery, road work, landscapers, utility workers, etc.

- a. For workers who do not work due to smoke conditions, develop provision allowing for claim of unemployment insurance under “good cause quit” to claim benefits. In addition, consider how to provide similar protection for undocumented workers.
- b. Require employers to keep records of employees who have been exposed to smoke like is already done for chemical exposures.

Research needed to support Solution C3:

- Need long term exposure research for outdoor workers.
- Assessment of the effectiveness of various strategies to support workers who have been harmed long-term.

..... **D. SOLUTIONS TO REDUCE HEALTH IMPACTS FROM SMOKE AND ASH OUTSIDE IMMEDIATE FIRE AREAS**

D1. Create a Health/Smoke Coordinated Game Plan (more than disconnected programs)

- a. Determine who has authority (state, regional, etc.) and create a coordinated and collaborative management approach.
- b. Identify funding for coordination and convening.
- c. Involve and engage key institutions beyond government agencies (e.g. hospitals, schools, nursing homes).
- d. Engage, from the beginning of the planning process, vulnerable populations/communities through working with community-based organizations.
- e. Identify and map impacted populations.
- f. Tie a coordinated smoke plan to planning for reducing pollution in communities that already suffer from high PM levels year-round.

Research needed to support Solution D1:

- Best practices: How are other states or provinces addressing smoke/health. management in a coordinated fashion when problems cross city/county boundaries?
- What has worked/not worked in managing fire/smoke events in California?

- When is AQI an appropriate index and when is it not? What are appropriate thresholds for action?
- Identify key smoke issues facing low-income and other vulnerable populations.
- What are the positive and negative impacts on vulnerable populations of strategies such as school closings?

D2. Develop equitable intervention solutions for different populations and environments with different degrees of smoke/ash risk. Smoke solutions for all, but with a special focus on access to solutions for vulnerable populations and communities.

- Convene interagency task force to identify best practices on smoke technologies.
- Create or improve solutions for individuals, buildings and communities.
- Clearly identify the most vulnerable populations and engage them in design and implementation of solutions (often not same as vulnerable groups for heat, flood, etc.)
- Secure funding to intervene at scale, including \$ earmarked for vulnerable communities.
- Put funding and distribution programs in-place before fires so they can be effectively implemented when a smoke event occurs.
- Improve overall health care access so individuals with asthma and other pre-existing conditions get needed care before fire/smoke events.
- Develop smoke-free centers in targeted communities similar to cooling centers for heat (and provide transportation for individuals who can't drive themselves).

Research needed to support Solution D2:

- Secure funding for evaluation of short- and long-term medical impacts of smoke.
- Understand how filtration technology works in different real-world contexts.
- What are low-cost approaches to creating safe environments inside buildings?
- How have other communities, states and countries made smoke solutions available and affordable for ALL?
- What are best strategies for outdoor populations? What strategies are effective and which are not?
- What measures are people taking and how effective are they?
- Review legal regulations (state laws, ordinances).

D3. Fund the development of low-cost technologies—sensors, masks, DIY filtration systems, etc.—that can be widely deployed.

- Deploy low-cost PM sensors spatially distributed in relevant locations—Indoor/outdoor, real time, high quality data quality.
- Develop and distribute low cost filtration systems—provide guidance, make widely available, full access for vulnerable groups.
- Provide individual masks—wide availability, low/no cost, guidance on how to use, including masks appropriate for children
- Align and integrate with state-funded weatherization programs.

Research needed to support Solution D3:

- How effective are masks for different smoke situations and affected groups?

D4. Develop and implement a Coordinated Communications Strategy. Establish clear and consistent messaging and guidance that is timely and tailored to different groups (public, private entities, individuals, etc.)

- a. Get multi-disciplinary/multi-stakeholder input.
- b. Establish triggers for messaging, content, and how to disseminate.
- c. Reach agreement on who has authority for different messaging and decision-making
- d. Provide practical guidance on what to do in specific situations, what to have, what to buy, etc.
- e. Use schools, community buildings/centers as models.

Research needed to support Solution D4:

- When is AQI an appropriate index and when is it not? What are appropriate thresholds for action?
- Social science – how do perceptions of risk affect behavior?
- Understand and identify best practices for effective communication.
- Evaluate existing California guidance(s).
- Develop better guidance and information based on how to communicate effectively in rural areas.

D5. Manage fires with a health lens. Deploy fire management strategies that reduce air quality impacts (in addition to reducing risks in WUI)

- a. Engage all CA communities and agencies to support improved fire management efforts.
- b. Focus preventative efforts in wildlands as well as WUI.

Research needed to support Solution D5:

- How to implement prescribed fire practices that accomplish the goal of reducing catastrophic fires but do not significantly degrade air quality.

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10. Ibid.
11. California's Fourth Climate Change Assessment (2018, August 27). Retrieved from <http://www.climateassessment.ca.gov/>
12. Watts et al. (Dec. 8 2018). The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. *The Lancet*, 392(10163). Retrieved from [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(18\)32594-7/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)32594-7/fulltext)
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APPENDIX A //

PROJECT PARTICIPANTS

UC Berkeley Workshop — April 30, 2019

Genevieve Taylor	AgInnovation
Erin Tou	Alameda County
Matt Beyers	Alameda County
Zerlyn Ladua	Alameda County
Erica Pan	Alameda County
Meg Arnold	ARCCA/Valley Vision
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Judith Cutino	Bay Area Air Quality Management District
Mike Wilson	BlueGreen Alliance
Mitch Steiger	California Labor Federation
Linda Rudolph	Center for Climate Change and Health
David Behar	City/County of San Francisco
Yeshe Salz	City/County of San Francisco
Meiling Gao	Clarity
Doug Wallace	Consultant
Nik Steinberg	Four Twenty Seven
Rick Diamond	Lawrence Berkeley Lab
Andy Jones	Lawrence Berkeley Lab
Brett Singer	Lawrence Berkeley Lab
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Nathan Bengtsson	PG&E
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Susan Stuart	Santa Clara County

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Craig Dawson	Sonoma State University
Curtis Brown	State of California (CalFIRE)
Jason Vargo	State of California (CDPH)
Meredith Milet	State of California (CDPH)
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Laura Stock	UC Berkeley (Labor Occupational Health Program)
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Sadie Frank	UC Berkeley (MDP)

John Balmes	UC Berkeley (School of Public Health) & CARB
Justin Remais	UC Berkeley (School of Public Health)
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Susie Kocher	UCANR
Robert Harrison	UCSF - CDPH
Kelan Stoy	Urban Footprint
Meredith Kurpius	US EPA Region 9
Doug Parker	Worksafe
Nicole Marquez	Worksafe

ARCCA Statewide Webinar — July 10, 2019

Steve Messner	360 Group
Sascha Petersen	Adaptation International
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Jeff Newman	Caltrans
Alex Schubek	City of Fremont
Mo Lahsaie	City of Oceanside
Rosie Dyste	City of Santa Barbara
Seth Jacobson	Climate Resolve
Kristopher Eclarino	Climate Resolve
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Ken Folsom	CSU Monterey Bay
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Norma Santiago	El Dorado County
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Karl Van Orsdol	Global Energy
Melanie Biesecker	Grid Alternatives
Pam Bold	High Sierra Energy Foundation
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Marguerite Young	Service Employees International Union
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Lizbeth Aguirre-Jaimes	State California Dept of Public Health
Alex Horangic	State of California Energy Commission
Monica Palmeira	State of California Public Utilities Commission
Jessie Ochoa Diaz	State of California Parks
Garry Bowen	Tahoe Future Forum
Alyssa Mann	The Nature Conservancy
Bill Seline	Truckee Fire Protection District
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Stakeholder Interviews

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Will Dominie	Bay Area Regional Health Inequities Initiative
Sam Appel	BlueGreen Alliance
Matt Wolff	City/County of San Francisco
Michael Kent	Contra Costa County
Kim Evon	Service Employees International Union
Jennifer Pezda	Sempra Utilities
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Anny Patino	UC Berkeley
Keith Gilles	UC Berkeley
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APPENDIX B //

LITERATURE REVIEW

Catalyzing California Action for Health, Wildfires and Climate Change
UC Berkeley — April 30, 2019

Health, Wildfire & Climate Change Literature Review V 2.0
Compiled by Sadie Frank, UC Berkeley

Send additions to: sadiefrank@berkeley.edu OR bruce@climatereadinessinstitute.org

SECTION I: ACADEMIC LITERATURE REVIEW

A: Evidence Reviews — British Columbia Centre for Disease Control (2014)

[LINKS for REPORTS 2-9 BELOW](#)

- 2014 collection of evidence reviews from the British Columbia Centre for Disease Control, with in depth PDFs on current evidence of wildfire and health related topics and associated literature.
- 2) Barn, Prabijit. (2014). Home and community clean air shelters to protect public health during smoke events.
 - 23-page overview of current literature on clean air shelters, includes key findings, gaps and considerations. While air filtration is a potential tool for reducing adverse health impacts, it remains an area for study. Main gaps identified include to date reporting only on 'best case' scenarios, lack of long term efficacy studies and technical gaps in filter type. *Includes 31 external references.*
- 3) Stares, Joanne. (2014). Use of evacuation to protect public health during wildfire smoke events.
 - 23-page overview of current literature on evacuations during smoke events, includes key findings, gaps and considerations. Main gaps identified include lack of evidence on evacuation effectiveness, as well as understanding how smoke surveillance and health-outcome surveillance fit into evacuation decision making. *Includes 34 external references.*
- 4) Dix-Cooper, Linda. (2014). Reducing time outdoors during wildfire smoke events: Advice to stay indoors, advice to reduce outdoor physical activity and cancelling outdoor events.
 - 25-page overview of current literature on reducing time outdoors during smoke events, includes key findings, gaps and considerations. Main gaps include broad cross-sectional studies of different kinds of geographies and vulnerable populations, as well as alternative communications like cell-phones and internet ext. *Includes 37 external references.*
- 5) Duran, Sandra. (2014). Wildfire smoke and public health risk.
 - 27-page overview of current literature on wildfires smoke and overall public health risk. Main

findings reflect understanding of health outcome pathways. Main gaps include emissions inventory, plume distribution and validating smoke component levels for WHO guidelines. *Includes 59 external references and appendices.*

- 6) Yao, Jiayun. (2014). Exposure measures for wildfire smoke surveillance.
 - 20-page overview of literature on smoke surveillance tools. Includes discussion of smoke surveillance methods, air quality monitoring and smoke forecasting tools. *Includes 64 external references.*
- 7) Keefe, Anya. (2014). Filtration in institutional settings during wildfire smoke events.
 - 19-page overview of current literature on use of indoor air filtration in institutional settings. Finds that HVAC system changes could impact adverse health outcomes especially in contaminant sealed rooms. However, evidence is limited and no research has been done on wildfire smoke specifically. *Includes 20 external references.*
- 8) Morrison, Katherine. (2014). Health surveillance for wildfire smoke events.
 - 26-page overview of literature on wildfire smoke surveillance tools. Includes discussion of smoke surveillance methods, air quality monitoring and forecasting tools. *Includes 64 external references.*
- 9) Sbihi, Hind. (2014). Using masks to protect public health during wildfire smoke events.
 - 20-page overview of current literature on mask usage during smoke events. Finds that respirators are useful at limiting particulate exposure, and that N95 masks are an effective and cost-effective option against particulate matter. However, on an individual-mitigation level further study is needed. *Includes 34 external references.*

B: Additional Academic Resources/Reviews on Wildfires and Health

Wildfires and Health, General

- 10) Black, Carolyn., Tesfaigzi, Johannes., Bassien, Jed., Miller, Lisa., (2017). Wildfire Smoke Exposure and Human Health: Significant Gaps in Research for a Growing Public Health Issue. *Environ Toxicol Pharmacol.* Oct; 55: 186–195. [LINK](#)
 - Recent literature review of current wildfire exposure and associated health impacts. Identifies known impacts on respiratory health and vulnerable populations, including children, pregnant women, populations with chronic health conditions and the elderly. Typified further research needs as: ‘improving air quality monitoring, prediction, and reporting’ and understanding impacts on vulnerable populations over larger time and geographic scales.
- 11) Balmes, JR (2018) Where There’s Wildfire, There’s Smoke. *New England Journal of Medicine.* 378(10). [LINK](#)
 - Overview of climate change’s effects on wildfires, associated health impact pathways and necessary information for medical practitioners and public health professionals. Characterizes challenges to prevention and mitigation, and mentions community based fire management.
- 12) Cascio, WE. (2018). Wildland fires and human health. *Science of the Total Environment.* 624:586-595. [LINK](#)
 - Review of current knowledge of wildland fires and overall population health. Identifies known

links between PM exposure and respiratory impacts, mixed evidence on cardiovascular impacts, and confirmed vulnerable populations of the elderly and pregnant women. Includes recommendations for further research.

13) Reid CE, Brauer M, Johnston FH, Jerrett M, Balme JR, Elliott CT. (2016). Critical review of health impacts of wildfire smoke exposure. *Environ Health Perspect* 124:1334–1343; [LINK](#)
- Review of current literature on health impacts of wildfire smoke exposure. Main findings are strong associations with respiratory morbidity and all-cause mortality. Gaps include mortality associated with wildfire smoke, cardiovascular outcomes, and impacts on vulnerable populations.

14) Elise Finlay, Sarah., Moffat, Andrew, Murray, Virginia. (2012) Health Impacts of Wildfires. *Public Library of Science*. [LINK](#)
- Review of health impacts of wildfires in the UK. Cites immediate mortality causes like deaths from burns and critical organ failures. Respiratory, cardiovascular and psychiatric health is impacted along with risks of water, air and land pollution. Calls for more research into long term impacts.

15) Liu, Jia., Pereira, Gavin., A. Uhl Sarah., A. Bravo, Mercedes., L. Bell Michelle. (2015). A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke. *Environ Res.* 120–132. doi:10.1016/j.envres.2014.10.015. [LINK](#)
- Systematic review of non-occupational health impacts from wildfire smoke. Main findings include respiratory outcomes, link between wildfire, pollution events and PM10. Challenges found include exposure measurement, separating ambient pollution from wildfire smoke, and assessing cardiovascular outcomes.

16) Ford, B., Val Martin, M., Zelasky, S. E., Fischer, E. V., Anenberg, S. C., Heald, C. L., & Pierce, J. R. (2018). Future fire impacts on smoke concentrations, visibility, and health in the contiguous United States. *GeoHealth*, 2, 229–247. [LINK](#)
- Climate projection study on future impacts of smoke related issues in the US. Found that while anthropogenic PM2.5 emissions will decrease, this will be offset by emissions from wildfires. Additionally, while total deaths related to PM2.5 will decrease, the absolute number premature deaths linked to PM2.5 will double.

17) W. Max Kirk, Madeline Fuchs, Yibo Huangfu, Nathan Lima, Patrick O’Keeffe, Beiyou Lin, Tom Jobson, Shelley Pressley, Von Walden, Diane Cook & Brian K. Lamb (2018) Indoor air quality and wildfire smoke impacts in the Pacific Northwest. *Science and Technology for the Built Environment*, 24:2, 149-159.
- Pacific Northwest study of air quality in homes during wildfire events. Measured particulate matter, ozone, and volatile organic compounds. Found that while being indoors did improve air quality, depending on pollution source, indoor air quality was still impacted by exterior wildfire smoke.

18) Richardson Leslie A., Champ, Patricia A., Loomis John B. (2012). The hidden cost of wildfires: Economic valuation of health effects of wildfire smoke exposure in So. California. *Journal of Forest Economics*. 14-35.
- Economic study on ‘true-cost’ of wildfire and health valuation after Los Angeles fires. Found that when defensive behavior is factored in to willingness to pay calculations, the cost of illness estimate per person went up from \$9.50 to \$84.42 a day.

19) Brey, Steven J., Barnes, Elizabeth A., Pierce Jeffrey R., Wiendinmyer, Christine., Fisher, Emily. (2018). Environmental Conditions, Ignition Type, and Air Quality Impacts of Wildfires in the South-eastern and Western United States. *Earths Future*. [LINK](#)

- Recent open access article on environmental conditions and ignition types of landscape fires in the Western US. Finds that both lightening and human caused fires are correlated with similar environmental conditions and that climate change is expected to impact both ignition sources similarly. Additionally, finds that particulate emissions mass is similar across the West and South-eastern US.

20) Condo, Michelle C., De Roos, Anneclair J., White, Lauren S., Heilman, Warren E., Mockrin, Mirand H., Gross-Davis, Carol Ann., Burstyn, Igor. (2019). Meta-Analysis of Heterogeneity in the Effects of Wildfire Smoke Exposure on Respiratory Health in North America. *International Journal of Environmental Research and Public Health*. [LINK](#)

- Very recent systematic meta-analysis of literature on respiratory health and wildfire smoke exposure in North America. Found a greater effect on females than males for asthma and chronic pulmonary disease, as well as a lower risk for young people than adults across all respiratory health indicators. Additionally, found stratified results for socioeconomic demographic variables but insufficient data to quantitatively evaluate.

21) Shusterman, Dennis., Kaplan, Jerod Z., Canabarro, Carla. (1993). Immediate Health Effects of an Urban Wildfire. *Western Journal of Medicine*. 158(2) [LINK](#)

- Retrospective review of emergency response and coroners records in early 1990's wildfires in Alameda County. Smoke constituted the majority of admissions, followed by burns and other minor trauma. All deaths involved burns.

22) Final Report: Wildland Fire Smoke Health Effects on Wildland Firefighters and the Public. (2017). United States Forest Service.

- USFS commissioned study on firefighters and public health risk from both prescribed and wild-fires. Found that among 83 firefighters at prescribed burns, and 417 at project wildfires, the Occupational Safety and Health Administration (OSHA) 8-hour exposure level of 50 ppm for CO was exceeded 3.5 percent of the time at prescribed fires and 5.6 percent of the time at project fires. Includes further findings on epidemiology of firefighter health risks.

Occupational Exposure

23) M. Navarro, Kathleen., Cisneros Ricardo., M. Noth, Elizabeth., Balmes, JR, S. Hammond, Katharine. (2017) Occupational Exposure to Polycyclic Aromatic Hydrocarbon of Wildland Firefighters at Prescribed and Wildland Fires. *Environmental Science and Technology*. 51 (11): 6461-6469. [LINK](#)

- Study of occupational exposure of California firefighters to PAH's in prescribed burns and wild-fires. Found more concentration during wildfires, and for firefighters closest to wildfire source. While PAH concentrations did not exceed occupational limits, better occupational exposure characterization is needed to understand long term health impacts.

24) Williamson, G J., Bowman D M J S., Price O F, Henderson S B, Johnston, F H. (2016). A transdisciplinary approach to understanding the health effects of wildfire and prescribed fire smoke regimes. *Environmental Research Letters*. 11

- Review of the health impacts of wildfires and prescribed fires from multiple disciplines and

modeling perspectives. Compares air pollutants, combustion properties, and smoke dispersal potential, while providing a framework to move towards improved smoke management regimes.

Vulnerable Populations

25) M. Holstius, David., E. Reid, Colleen., M. Jesdale, Bill., Morello-Frosch, Rachel. (2012). Birth Weight following Pregnancy during the 2003 Southern California Wildfires. *Environ Health Perspect* 120:1340–1345. [LINK](#)

- UC Berkeley study on birth weights for pregnant mothers exposed to the 2003 wildfires. Results show statistically significant declines in mean birth weights for all trimesters.

26) Brown, Michael et al. (2019) After the Fort McMurray wildfire there are significant increases in mental health symptoms in grade 7–12 students compared to controls. *BMC Psychiatry*. [LINK](#)

- Recent study comparing adolescent populations affected by a wildfire disaster. Found statistically significant increases in mental health symptoms (depression, tobacco use, suicidal thoughts) for communities impacted by fire.

27) Miller, Lisa A. Persistent Immune Effects of Wildfire PM Exposure During Childhood Development. (2013). California Air Resources Board. [LINK](#)

- CARB study evaluating the effects of wildfire smoke on rhesus monkeys during the 2008 wildfire season in California. Demonstrated significantly reduced immune functions in association with lung function detriments between treatment and control populations. Suggests that these findings can serve as biological sentinels for human population effects of ambient air pollution.

28) Wettstein, Z. S., Hoshiko, S., Fahimi, J., Harrison, R. J., Cascio, W. E., & Rappold, A. G. (2018). Cardiovascular and Cerebrovascular Emergency Department Visits Associated with Wildfire Smoke Exposure in California in 2015. *Journal of the American Heart Association*. [LINK](#)

- Analysis of emergency room visits during the 2015 California wildfire season. Found that smoke exposure was associated with increased visits for cardiovascular and cerebrovascular disease with greatest risk among elder adults above 65.

Intervention Efficacy

29) Fisk, W. J., Chan, W. R. (2017). Health benefits and costs of filtration interventions that reduce indoor exposure to PM_{2.5} during wildfires. *Indoor Air*. 27(1):191-204. [LINK](#)

- Health and economic study of estimated costs and benefits to homes with indoor air filtration interventions among mortality outcomes. Study shows reduced likelihood of hospital admissions, with cost exceeding overall benefits and benefits exceeding costs among non-portable air filter interventions.

30) Yap, Poh-Sin, Garcia, Cynthia. Effectiveness of Residential Wood-Burning Regulation on Decreasing Particulate Matter Levels and Hospitalizations in the San Joaquin Valley Air Basin. (2015). *Research and Practice*. [LINK](#)

- Study evaluating the effects of Rule 4901, a residential wood burning regulation that went into effect in 2003 for the San Joaquin Valley Air Basin. Found that the rule was successful at reducing ambient particulate matter and additionally successful at reducing hospital emissions for heart disease among elder adults.

Land Use/Forecasting

31) Butsic, Van., Kelly, Maggi. A. Moritz, Max. (2015). Land Use and Wildfire: A Review of Local Interactions and Teleconnections. [LINK](#)

- Literature review of land use and fire impacts. Describes the complex feedback loops between land use and fire management, and calls for a land based teleconnection approach where teleconnection is defined as “climate anomalies that correlate over large geographic distances.”

32) Vaidyanathan Ambarish., Yip, Fuyuen., Garbe, Paul., (2018). Developing an online tool for identifying at-risk populations to wildfire smoke hazards. *Science of The Total Environment*

V:619–620, 1 P: 376-383. [LINK](#)

- Overview of current online tool being developed by the CDC that “utilizes short-term predictions and forecasts of smoke concentrations and integrates them with measures of population-level vulnerability for identifying at-risk populations to wildfire smoke hazards”.

SECTION II: GREY LITERATURE REVIEW

A: Public Facing Reporting and Guidance on Wildfires and Health

Association of Bay Area Governments & Metropolitan Transportation Commission. (2018).

Bay Area Wildland Urban Interface Review of Risks, Plans, and Strategies. [LINK](#)

- White paper exploration of current community level strategies to reduce wildfire risk.

Reardon, Sara. (2018). *Raging wildfires send scientists scrambling to study health effects*. Nature.

[LINK](#)

- Reporting on in-progress wildfire and health studies addressing gaps in air pollution literature around smoke chemical makeup.

Grossman-Ruiz, Sarah. (2019). *Water in Paradise Is Contaminated, Undrinkable After California’s Camp Fire*. Huffington Post. [LINK](#)

- Reporting on the current water contamination crisis in Paradise CA post wildfire. Currently 40% of water lines in the town show elevated levels of benzene, a carcinogen.

Bernstein, Sharon. (2019). *A growing problem after California wildfires: Toxic chemicals*. [LINK](#)

- Reporting on current efforts to quantify and understand the impacts of wildfire ash and chemical composition on urban and semi-urban areas after the 2018 fire season.

Union of Concerned Scientists. Western Wildfires and Climate Change. PDF Report. [LINK](#)

- Panel factsheet on climate change and wildfires in the Western US.

EPA wildfire smoke fact sheet. Reduce your smoke exposure. [LINK](#)

- Current public facing EPA guidelines for reducing smoke exposure.

EPA Wildfire Smoke: Public Health Planning Guide. (2016) [LINK](#)

- Current EPA health planning guide for wildfire events.

Worksafe BC. Wildfire Smoke: Frequently Asked Questions. (2017). [LINK](#)

- Current occupational wildfire FAQ’s for British Columbia.

British Columbia Centre for Disease Control. Guidance for BC Public Health Decision Makers During Wildfire Smoke Events. (2014) [LINK](#)

- Summary of all BCDC evidence reviews provided in academic literature review.

British Columbia Public Health. BC Health Wildfire Smoke Response Coordination Guideline. (2017) [LINK](#)

- Coordination and strategy guideline for stakeholders and decision makers in smoke response departments in BC. Describes how the document 'will support regional response to a wildfire smoke event that may impact the health of a population in BC.'

Washington State Department of Natural Resources: Commissioner Franz, Senate Democrats Release Historic Wildfire and Forest Health Funding Bill. [LINK](#)

- Reporting on massive new WA state bill to fund preventative forest management.

Berkeley Fire Research Group. Towards Controlling Wildfires by Harmonizing Engineering Technology and Environmental Approaches [LINK](#)

B: Comprehensive Guides to Climate Change and Health

A Call to Action on Climate and Health. (2018). Global Climate and Health Forum [LINK](#)

- Comprehensive CTA produced for the 2018 GCHF. Includes climate, health, and financing actions.

Health and Climate Resource Guide. (2018). American Public Health Association. [LINK](#)

- Comprehensive APHA resource guide on climate and health. Includes key partners, challenge area breakdowns and audience specific resources.

Rudolph, L., Harrison, C., Buckley, L. & North, S. (2018). Climate Change, Health, and Equity: A Guide for Local Health Departments. Oakland, CA and Washington D.C., Public Health Institute and American Public Health Association. [LINK](#)

- Guide to climate and health equity planning for public health departments.

Lancet Countdown: Tracking Progress on Health and Climate Change: [LINK](#)

Lancet tracker of 41 indicators across key areas of climate and health related statistics.

National Resources Defense Council Issue Briefing. Climate Change and Health in California. [LINK](#)

- Comprehensive issue briefing on the California context for climate/health, with calls to action.

California Senate Office of Research. (2018). Climate Change and Health: Understanding How Global Warming Could Impact Public Health in California. [LINK](#)

- Comprehensive overview by the State Senate of the current and projected health challenges from climate change and California.

US Global Change Research Program. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. [LINK](#)

- Current overview of climate change and health impacts to date in the United States, with future projected impacts in defined risk areas.