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About the Journal

The Journal of the Wildfire Conservancy is a scientific, peer-reviewed journal supported by the Wildfire Conservancy and the Wildfire Science and Urban Interface Program at California State University San Marcos. We publish a variety of new and innovative papers, articles, and manuscripts that help to advance our mission of research, education, and outreach, with a focus on wildfires and the wildland urban interface. The primary focus of the Journal is to highlight research that can have practical application and implementation by company officers, firefighters, decision makers, and legislators, to bridge the divide between science and policy. Contributions to this Journal should focus on good science and include practical applications for that science. The Journal contributes to the advancement of three specific areas of emphasis:

- Improving Firefighter Health and Safety
- Advancing Attack Effectiveness
- Promoting Community Resilience and Awareness

The Journal publishes articles focused on basic and applied research in an open-access, online publication that supports innovation and progress toward the advancement of wildland and urban interface fire issues. All content is free to the public to download, copy, and print; this supports our focus of bringing science to the practitioners and decision makers. Articles may include links to informative videos, training modules, data, and supporting posters/brochures that fire departments, local, state, federal, and tribal governments, organizations, and the public can download and use as tools for advancing training and understanding.

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WILDFIRE CONSERVANCY ANNUAL SYMPOSIUM

ADVANCING FIREFIGHTER HEALTH, SAFETY, AND RESEARCH INFRASTRUCTURE IN CALIFORNIA – RESPONDING TO THE LOS ANGELES FIRE SIEGE AND BEYOND

Prepared by: Matt Rahn, PhD, MS, JD, Kelcey Stricker, DrPH, MS

Executive Summary

This multi-session symposium convened experts, researchers, students, and fire service professionals to confront urgent issues facing firefighter health and safety. The key topics spanned occupational cancer, toxic exposures, personal protective equipment (PPE) advancement, respiratory protection, behavioral health, post-exposure assessment, and the institutional infrastructure needed to support sustained research and policy development.

Key Themes & Findings

1. **Modern Fire Risks Require Modern Solutions:**
    - Wildland Urban Interface (WUI) fires dominate California's landscape, involving synthetic and battery-based hazards far beyond traditional wildfires.
    - Firefighting remains rooted in century-old practices and underregulated exposure protocols.
2. **Urgent Need for Respiratory and PPE Innovation:**
    - Cal-OSHA is spearheading a regulatory shift to mandate usable, field-tested respiratory protection like Powered Air Purifying Respirators (PAPRs).
    - PPE trade-offs (protection vs. heat stress/mobility) demand modular, evidence-based designs supported by real-world testing.
3. **Institutional Barriers Slow Progress:**
    - Bureaucracy, cultural resistance, and funding silos hinder collaboration between fire departments and researchers.
    - Regulatory frameworks (e.g., National Institute for Occupational Safety and Health [NIOSH], National Fire Protection Association [NFPA]) lag behind field conditions, limiting innovation.
4. **Research Infrastructure Must Evolve:**
    - Statewide coordination, baseline biomonitoring, centralized biorepositories, and mobile labs are essential.
    - The Firefighter Cancer Cohort Study (FFCCS) and air curtain PPE prototypes exemplify the value of long-term, applied, and participatory research.
5. **Behavioral Health is a Parallel Crisis:**
    - Post Traumatic Stress Disorder (PTSD), addiction, and suicide rates remain high.

    - A California Center of Excellence is being developed to address this crisis with culturally competent, accessible care.

6. **Policy Must Align with Science:**
    - Legislator education (e.g., bootcamps), clearer communication, and fire labor engagement are key to embedding scientific evidence in decision-making.

Strategic Recommendations

- Institutionalize **tiered post-exposure assessment protocols** and integrate research teams early into incident response.
- Develop and regulate **wildland/WUI-specific PPE and respiratory protection** through phased pilot programs and firefighter co-design.
- Expand **longitudinal health monitoring** using centralized data platforms and wearable/exposure tracking.
- Launch and fund the **California Behavioral Health Center of Excellence** and ensure retirees and dispatchers have service access.
- Encourage cross-agency collaboration and **statewide clearinghouses** to eliminate redundancy and improve research translation.
- Prioritize **real-world relevance** in all research agendas—studies must solve current problems and guide future safety innovations.

Conclusion

The current approach to firefighter health and safety in California is outdated, fragmented, and ill-equipped to meet the rising threat of toxic exposures, psychological trauma, and modern fire behavior. However, through strategic investment in research, infrastructure, and collaboration—anchored by firefighter engagement—California has the opportunity to lead the nation in redefining and modernizing firefighter health and operational safety for decades to come.

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List of Acronyms

ADU-Accessory Dwelling Units

ALS-Amyotrophic Lateral Sclerosis

AMH-Anti-Müllerian Hormone

APF-Assigned Protection Factor

APR-Air Purifying Respirator

ASTM-American Society for Testing and Materials

CAL FIRE-California Department of Forestry and Fire Protection

Cal/OSHA-California Division of Occupational Safety and Health

CO-Carbon Monoxide

CO_2-Carbon Dioxide

CPF-California Professional Firefighters

EMS-Emergency Medical Systems

ESS-Energy Storage Systems

FFCCS-Fire Fighter Cancer Cohort Study

IAFF-International Association of Fire Fighters Labor Organization

IARC-International Agency for Research on Cancer

IC-Incident Command

IDLH-Immediately Dangerous to Life or Health

L2881-IAFF Local 2881 Union (CAL FIRE)

MOF-Metal-Organic Framework

NFPA-National Fire Protection Association

NIOSH-National Institute for Occupational Safety and Health

OSHA-Occupational Safety and Health Administration

PAPR-Powered Air Purifying Respirator

PPE-Personal Protective Equipment

PTSD-Post Traumatic Stress Disorder

Q&A-Question and Answer

R&D-Research and Development

RPE-Respiratory Protective Equipment

SCBA-Self-Contained Breathing Apparatus

VOC-Volatile Organic Compounds

WUI-Wildland Urban Interface

A DISCUSSION OF RESEARCH LOGISTICS, COLLABORATION, AND SUPPORT

Dr. Matt Rahn
The Wildfire Conservancy

Summary

Dr. Matt Rahn provided an introductory session focused on the need for stronger institutional support, improved communication, and cultural change to advance firefighter-related health and safety research. He highlighted both the opportunities and barriers that fire departments and researchers face when trying to collaborate effectively—particularly in the aftermath of major incidents like battery fires or wildland-urban interface (WUI) events. The discussion emphasized the importance of collecting timely exposure data, fostering trust between researchers and fire services, and ensuring research addresses real-world operational needs. Participants also discussed how bureaucratic and logistical challenges—such as funding limitations, travel restrictions, and cultural resistance—hamper meaningful progress.

Key Takeaways

1. **Early Incident Access Is Critical**
    - Valuable exposure data is often missed because researchers are not embedded early in fire responses.
    - Operational barriers and mistrust about the purpose of research can prevent access.
2. **Cultural Shifts Are Needed in the Fire Service**
    - There is resistance within the fire service to accept outside help or new practices (e.g., cleaning PPE, using respiratory protection).
    - Firefighters often fear being penalized for non-compliance if researchers or regulatory bodies are present.
3. **Communication and Information Sharing Are Lacking**
    - There's no central platform for departments and researchers to report unusual incidents or share needs.
    - Researchers often pursue disconnected projects that don't align with actual fire service priorities.
4. **Research Must Be Operationally Relevant**
    - Studies must answer practical questions for firefighters, not academic curiosities (e.g., studies on ice cream consumption are seen as wasteful); researchers must understand the job and day-to-day operations of firefighters to develop relevant research projects
    - Firefighters value research more when it helps them today or helps future generations.
5. **Funding and Institutional Constraints Limit Progress**
    - State mandates to keep research funding in-state can limit collaboration with national experts and institutions already equipped to do the work.
    - Some projects are duplicative because they prioritize institutional interests over firefighter needs.

Recommendations

1. **Establish a Central Research Clearinghouse**
    - Create a platform (e.g., a website or app) where departments and researchers can share data, ask questions, and report incidents.
    - Include case studies to show successful research collaborations and outcomes (e.g., San Diego battery fire analysis).
2. **Integrate Researchers Earlier in Incident Command**
    - Present at annual incident command (IC) meetings to build relationships and reduce resistance to research presence during incidents.
    - Define protocols for safe, non-intrusive researcher integration into active scenes.
3. **Foster Cultural Buy-in**
    - Shift the narrative from regulation and compliance to collaboration and support.
    - Emphasize that research is firefighter-driven and aims to improve current safety and future outcomes.
4. **Prioritize Research Relevance and Practical Outcomes**
    - Align research agendas with fire service-identified needs via surveys and direct engagement.
    - Avoid redundant or low-impact projects; prioritize studies that can influence policy, PPE, and health outcomes.
5. **Optimize Use of Resources**
    - Collaborate with existing expert institutions (even out-of-state) instead of duplicating efforts locally.
    - Advocate for flexible funding policies that emphasize impact over geography.
6. **Develop California-Based Capabilities (Selectively)**
    - Build or support California lab capacity only when it clearly fills a gap (e.g., faster processing of exposure data).
    - Avoid funding duplicative labs when capable partners already exist elsewhere.

Conclusions

- Institutional support must evolve from rigid bureaucracies into agile, collaborative frameworks that allow real-time data collection, cross-agency partnerships, and fire service-driven research.
- Cultural transformation in the fire service—from defensiveness to proactiveness—is key to embracing science that can improve safety and health.
- Resources must be used strategically, avoiding wasteful duplication and focusing instead on solving problems that matter most to firefighters.
- A coordinated, statewide approach—facilitated by a central clearinghouse—can ensure that research is effective, timely, and widely adopted.

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CANCER RESEARCH WITH THE WILDFIRE CONSERVANCY: AN OVERVIEW

Dr. Kelcey Stricker, Dr. Matt Rahn

Summary

This session introduced the cancer research initiatives emerging from recent large-scale fire incidents in California, particularly the Palisades and Eaton fires. These events highlighted the severe occupational exposures faced by firefighters and other responders due to the rise of Wildland-Urban Interface (WUI) fires. The presentation emphasized that current technology, safety protocols, and protective equipment are not keeping pace with modern fire risks—especially considering the combustion of synthetic materials, lithium-ion batteries, and prolonged fire durations.

The need for a "moonshot" approach to firefighter health and safety was discussed, especially in terms of cancer risk, respiratory and dermal protection, and effective personal protective equipment (PPE). The session also focused on leveraging data and science to inform public policy and resource allocation. The integration of early researcher access during the Palisades and Eaton fires allowed for timely collection of biological samples and exposure data, making this one of the most robust datasets ever collected on a fire of this scale.

Key Takeaways

1. **Fire Incidents Are No Longer Traditional "Wildfires"**
   - The term "wildfire" is outdated. Most fires today are Wildland Urban Interface (WUI) events, involving combustion of synthetic, hazardous materials.
   - Fires now occur year-round; there is no longer a "fire season."
2. **Occupational Exposure Risks Are Underestimated**
   - The magnitude of exposure in recent events was compared to or exceeded 9/11 in some respects.
   - Many firefighters went over 60 hours without rest or adequate decontamination, highlighting both physical and toxicological risks.
3. **Data Collection Success**
   - Early deployment of researchers allowed for the collection of over 100 urine samples and dozens of silicone wristbands for exposure tracking—one of the most comprehensive efforts of its kind.
   - Data will help assess cancer risk, respiratory hazards, and dermal exposures.
4. **Technology and PPE Are Outdated**
   - The Pulaski tool, invented in 1910, is still widely used—underscoring how little has changed in wildland firefighting over a century.
   - Modern threats require modern protective strategies and equipment.
5. **Second Responders Are Overlooked**
   - Utility workers, law enforcement, and public works crews operating behind fire lines are often exposed to the same conditions without proper PPE or training.
6. **Gap Between Research and Policy**
   - Legislative decision-makers often

lack the scientific understanding to prioritize fire service needs.

- The creation of a legislative bootcamp aims to educate policymakers and build bridges between science and public policy.

Recommendations

1. **Redefine Fire Terminology and Risk Awareness**
   - Shift public and internal terminology to "WUI fires" and "fire year" to better reflect the current scope of risks.
   - Promote this language change in communications, reports, and policy advocacy.
2. **Accelerate PPE Modernization**
   - Support development and deployment of advanced PPE that addresses both structural and WUI environments.
   - Prioritize funding and testing of innovative equipment tailored to modern fire exposures.
3. **Institutionalize Early Incident Research Access**
   - Create standardized protocols for safely embedding research teams at fire incidents without operational disruption.
   - Make early data collection a core objective of major response efforts.
4. **Expand Health Surveillance to All Response Roles**
   - Ensure non-firefighting personnel (e.g., utility crews, law enforcement) receive appropriate respiratory and dermal protection during WUI incidents.
   - Include these groups in occupational health surveillance programs.
5. **Align Research with Real-World Needs**
   - Conduct studies that directly impact firefighter safety, operational effectiveness, and equipment investment decisions.
   - Avoid low-impact or redundant research that does not translate to practical outcomes.
6. **Strengthen Policy-Research Integration**
   - Continue and expand efforts like the legislative bootcamp to help bridge the gap between science and government.
   - Engage fire labor organizations (e.g., CPF, Local 2881) to advocate for legislative change grounded in science.

Conclusions

The traditional wildfire response model is no longer adequate in the face of modern WUI fires. Firefighter health and safety require a comprehensive overhaul—a "moonshot"—involving updated terminology, early data collection, PPE reform, and greater integration of research into public policy. The early collaboration between researchers and CAL FIRE during the Palisades incident sets a new standard for proactive data collection and occupational health research, but this must be institutionalized and scaled to ensure systemic improvements across California and beyond.

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FIREFIGHTER CANCER COHORT STUDY

Dr. Burgess
University of Arizona

Summary

Dr. Jeff Burgess provided an overview and update of the Firefighter Cancer Cohort Study (FFCCS), emphasizing the long-term health monitoring of firefighters—especially following major incidents such as the 2025 Los Angeles fires. He detailed the collection of biological samples (blood, urine, and wearable wristbands) to assess exposure to hazardous substances like per- and polyfluoroalkyl substances (PFAS), polycyclic aromatic hydrocarbons (PAHs), and various metals. The aim is to better understand the relationship between exposure and long-term health outcomes such as cancer, reproductive harm, and stress-induced cellular changes. Dr. Burgess stressed the value of pre- and post-exposure data for precise comparisons, leveraging collaborations with departments like CAL FIRE and the City of Los Angeles.

Key Takeaways

1. **Long-Term Study Goals:**
   - FFCCS aims to enroll over 10,000 firefighters and follow them for 30 years to study cancer and other health risks.
   - The National Firefighter Registry does not collect biological samples; FFCCS fills that critical gap.
2. **Biological Monitoring:**
   - Samples include blood, urine, and wristbands to measure exposures to:
     - PFAS (forever chemicals)
     - PAHs (from combustion)
     - Flame retardants, pesticides, phenols, phthalates
     - Metals and oxidative stress markers
3. **Value of Pre-Incident Data:**
   - Over 450 firefighters had PFAS testing within 8 months before the incident, providing a rare opportunity for pre- versus post-exposure comparisons.
4. **Advanced Biomarkers and Testing:**
   - Plans to test over 11,000 proteins in blood samples.
   - Use of epigenetic markers to evaluate long-term cancer risk.
   - Investigation of oxidative stress markers to inform potential antioxidant interventions.
5. **Participant Recruitment:**
   - Over 7,300 enrolled in FFCCS so far, including a large number of wildland and WUI firefighters.
   - Active recruitment ongoing with a goal of reaching 1,000 participants from the LA fire incidents.

Recommendations

1. **Expand Enrollment:**
   - Continue efforts to recruit more firefighters, particularly those exposed and unexposed, to improve comparative analysis.

2. **Institutionalize Baseline Testing:**
    - Fire departments should implement routine pre-incident biological monitoring to enable future comparisons.
3. **Develop Local Testing Capacity:**
    - Establish regional labs or mobile units for faster analysis and reduced sample loss due to logistical challenges.
    - Increased local capacity can allow for increased number of participants (sample size) due to reduced transit times for time-sensitive biological samples and increased operational hours (e.g. shorter transit times equate to more days of the week samples can be shipped for expedited processing).
4. **Educate Firefighters on Health Risks:**
    - Provide clear guidance on interpreting biomonitoring results and avoiding unproven detox remedies or supplements.
5. **Collaborate on Intervention Research:**
    - Explore controlled studies on antioxidants and other interventions to mitigate short term (acute) and long-term (chronic) effects of toxic exposures.

Conclusions

- The FFCCS is a pioneering initiative that captures critical exposure and health data in a longitudinal framework.
- The integration of pre- and post-exposure data provides a powerful model for assessing the impact of fire-related hazards.
- This research will not only help identify cancer and disease risks but may also inform policy, equipment design, and health monitoring practices.
- Fire service leadership, medical professionals, and policymakers should support and leverage this infrastructure to safeguard firefighter health for future generations.

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Summary

Following his presentation, the Symposium participants then engaged in a question and answer (Q&A) session focused on the health risks and scientific responses to toxic exposures faced by firefighters—especially in wildland-urban interface (WUI) and modern urban conflagrations. The discussion spanned topics including the selection and measurement of toxic metals in blood and urine, the evolution of our understanding of risk and exposure over decades, new threats such as lithium-ion battery fires, the logistics of biomonitoring and sample analysis, firefighter cancer risks, reproductive health concerns, and the need for systematic, sustainable research frameworks. One of the notable themes was that modern WUI fires and large conflagrations, such as the Palisades and Eaton fires, should be treated much like the exposures from the fall of the World Trade Center in 2001. The risks are substantial, and may even exceed, the kinds of exposures we saw nearly 25 years ago in New York.

Key Takeaways

1. **Evolving Chemical Exposures:**
    - Firefighters are now facing more complex chemical exposures compared to past decades, due to changes in building materials (e.g., plastics, composite wood, lithium-ion batteries), while also experiencing serious risk from older homes and materials that have since been removed from modern construction (e.g. asbestos and lead).
    - The conversation reflects concern that exposure profiles have shifted significantly, especially with the rise of battery-powered devices and newer synthetic materials.
2. **Biomonitoring and Toxicology:**
    - Biomonitoring includes testing blood and urine for metals like lead, arsenic, and lithium, with differing protocols depending on metals.
    - Wristbands are being used to detect exposure to volatile and semi-volatile compounds not easily tested in traditional samples, and act as a passive sampling device during duty.
    - There is a strong push to analyze not just known harmful substances (e.g., PFAS, PAHs) but a broader spectrum of chemicals whose toxicity is still uncertain.
3. **Logistical Challenges:**
    - Sample collection and transport logistics (e.g., rapid blood sample delivery within 24 hours, dry ice availability, lab readiness) are major hurdles in effective data collection.
    - There's a call for a centralized or mobile California-based lab infrastructure to streamline the process.
4. **Research and Sustainability:**
    - Longitudinal research, modeled after studies like the Framingham Heart Study and Nurses Health Study, is essential to understand long-term health outcomes like cancer or amyotrophic lateral sclerosis (ALS) in firefighters.

- There's an emphasis on building sustainable, statewide databases and repositories to facilitate long-term epidemiological studies.

5. **Health Effects Beyond Cancer:**
   - Discussions touched on stress, mental health, epigenetics (biological aging), and reproductive health—highlighting how chemical exposures may have a wide-ranging impact.
   - Female firefighters' reproductive health and PTSD correlations are areas of ongoing and needed research.
6. **Independent Supplements Use:**
   - Firefighters, in the absence of official guidance, are turning to unregulated supplements and treatments for "detoxification," which raises safety concerns.
7. **Policy and Prevention Needs:**
   - There's an urgent need for legislation and industry standards to evaluate the toxicity of modern materials post-combustion.
   - Proposition 65 in California is seen as a possible model for tracking and mandating disclosures of hazardous chemicals in consumer products used in structures.
8. **New Fire Risks:**
   - Energy storage systems (ESS) (e.g. home battery storage systems) and e-bike fires represent growing occupational exposure threats; firefighters are responding to these fires often without appropriate self-contained breathing apparatus (SCBA) use, compounding health risks.
9. **Collaboration and Coordination:**
   - Researchers stress the need for multidisciplinary collaboration and data-sharing to avoid siloed efforts and to respond quickly to emerging threats.

Recommendations

1. Enhance Biomonitoring Capabilities

- **Establish a California-based laboratory or mobile processing lab** for rapid analysis of blood and urine samples to reduce reliance on out-of-state labs and improve turnaround time.
- **Create mobile units** equipped for on-site exposure assessment and sample processing during or immediately after fire events.
- **Expand wristband monitoring** to detect a broader range of volatile and semi-volatile compounds not typically captured in blood or urine.

2. Broaden Exposure Testing and Data Collection

- **Include emerging contaminants** such as lithium and other battery combustion byproducts in testing panels.
- **Develop indices or exposure profiles** instead of tracking isolated compounds, to better reflect the complex mix of toxic exposures firefighters encounter.
- **Capture initial exposure data promptly**, including pre- and post-shift sampling, to ensure accuracy and minimize data loss from delayed collection.
- **Utilize epigenetic markers** to assess long-term cancer risks and cellular aging caused by toxic exposures.

3. Improve Research Infrastructure and Sustainability

- **Create a long-term, statewide firefighter health cohort study**, modeled after studies like Framingham Heart Study and Nurses' Health Study,

with the aim of identifying chronic health risks (e.g., cancer, ALS, reproductive harm).

- **Develop and maintain a centralized biorepository** of biological samples for future testing as new risks emerge.
- **Standardize data collection and methodologies** across fire departments and studies to ensure compatibility and broader applicability.

4. Address Health Risks Beyond Cancer

- **Study and track reproductive health effects** in both male and female firefighters, with emphasis on including the use of anti-Müllerian hormone (AMH) levels and PTSD correlations in female firefighters.
- **Include mental health and stress evaluations** as part of comprehensive firefighter health monitoring.
- **Monitor for reproductive effects in wildland firefighters**, particularly related to chronic exposures.

5. Support Informed Health Decisions

- **Create research supported guidance on supplements and detoxification practices** to combat misinformation and unsafe self-treatment by firefighters.
- **Survey firefighters about their use of supplements** and compare outcomes with biomonitoring data to assess efficacy and risk.

6. Expand Training, Education, and Policy Engagement

- **Train firefighters and departments on sample collection protocols** and the importance of early data gathering.
- **Engage policymakers and fire service leadership** in supporting systematic health surveillance and prevention strategies.
- **Leverage Proposition 65** (California's chemical disclosure law) as a mechanism to mandate pre-market toxicity disclosures for building materials and consumer products used in homes. Use these disclosures to better understand firefighters' potential exposure during fire incidents at a large-scale, population level.

7. Modernize Fire Safety Codes and Product Oversight

- **Evaluate combustion toxicity of new materials** (e.g., composite decking, foam insulation, battery systems) and require hazard disclosures prior to market approval.
- **Incorporate combustion health risk assessments** into building codes and environmental reviews for products and technologies like energy storage systems and ADUs (Accessory Dwelling Units).
- **Assess firefighter exposure risks from energy storage systems and e-bike fires**, and develop relevant PPE, training, and safety standards.

8. Foster Collaboration and Information Sharing

- **Encourage interdisciplinary collaboration** among researchers, fire departments, and public health agencies to avoid duplicative work and improve response time.
- **Create a common database and platform** for data sharing, tracking firefighter exposures and outcomes across incidents and regions.

Conclusions

- Firefighter health risks are evolving rapidly due to modern materials and technologies. Current scientific understanding and infrastructure are struggling to keep pace.
- Systematic, sustained research with standardized data collection, mobile labs, and biorepositories is essential.
- There's a strong call for improved cooperation between fire departments, academic researchers, and policymakers to address logistical, scientific, and regulatory challenges
- Investments in preventive health measures, policy changes (e.g., testing and disclosure laws), and responsive infra**structure are necessary to protect both firefighters and the general public.**

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IMPROVING POST-EXPOSURE ASSESSMENTS FOR FIREFIGHTERS

Dr. Kelcey Stricker, Dr. Matt Rahn

Summary

This session focused on the urgent and unmet need for a standardized, evidence-based **post-exposure assessment protocol** for firefighters following major incidents involving toxic exposures. Despite repeated large-scale events (e.g., 9/11, Camp Fire, Lahaina), there is still no consistent guidance or infrastructure for what medical testing should occur, when, and how to interpret or use the data. The discussion emphasized the need for tiered guidelines, centralized systems, early incident data collection, logistical solutions, and a culture of follow-through and communication with firefighters.

Key Takeaways

1. **Lack of Standard Protocols**:
   - No national or state-level guidance or standards exist for post-exposure medical testing for firefighters.
   - Departments operate in an ad hoc manner, leading to inconsistent practices and data gaps.
2. **Clinical and Research Disconnect**:
   - Data is collected (e.g., PAHs, heavy metals), but often not tied to clinical guidance or actionable next steps.
   - Firefighters receive lab reports with no clear interpretation or follow-up, leading to confusion or mistrust.
3. **Need for Tiered Response Guidelines**:
   - A scalable, tiered framework based on exposure severity or incident type is needed to guide testing (e.g., blood/urine for metals, PAHs, CO).
   - Should specify what to test, when, and how to use these results, both clinically and for occupational health monitoring.
4. **Data Without Action Undermines Trust**:
   - Repeated failure to provide clear explanations or follow-up erodes firefighter trust in wellness programs and research studies.
   - Cultural resistance and fear of punitive outcomes remain barriers.
5. **Surveillance Infrastructure is Inadequate**:
   - California's fragmented system (e.g., one part-time physician at CAL FIRE) limits the ability to scale consistent health surveillance.
   - Local variations in testing and physician judgment create inequity and inconsistency.
6. **Logistical Barriers**:
   - Inability to deploy phlebotomists or sample collectors to incident sites hinders timely data collection.
   - Practical solutions like portable CO monitors and embedded responders have not been scaled or institutionalized.

7. **Behavior and Strategy Matter**:
    - PPE alone isn't enough—tactics (e.g., avoiding mop-up in high-exposure zones), personal hygiene, and rest patterns influence exposure.
    - Cultural and leadership buy-in are essential for changing behaviors.
8. **Research Is Progressing, But Slow**:
    - New data is emerging (e.g., showering reduces PAHs, dermal wipes may help), but integration into protocols is lacking.
    - Some persistent exposures (like PFAS) now have guidance; others do not.

Recommendations

1. **Develop and Implement Tiered Exposure Guidelines**:
    - Establish minimum and expanded post-exposure testing protocols based on incident severity.
    - Include specific recommendations for different toxins (e.g., PAHs, CO, PFAS, lithium-related compounds).
2. **Create a Centralized Statewide System**:
    - Designate regional clinical centers and electronic registries for firefighter health data.
    - Enable aggregation of anonymized data for surveillance and early trend detection.
3. **Formalize Rapid Response Teams**:
    - Integrate trained personnel and lab access into incident management teams to enable early sample collection.
4. **Improve Communication and Follow-Up**:
    - Provide clear, timely, and individualized feedback to firefighters.
    - Accompany test results with interpretation, risk communication, and actionable next steps.
5. **Institutionalize Monitoring Technologies**:
    - Explore feasible, embedded tools for CO and toxicant monitoring during incidents.
    - Support research and development (R&D) on rugged, real-time biosensors (e.g., wearable carboxyhemoglobin monitors).
6. **Align Research with Clinical Practice**:
    - Use findings to inform policies, not just publish data.
    - Link research projects with firefighter wellness and training efforts to foster relevance and engagement.
7. **Secure Sustainable Funding**:
    - Allocate state funds for health monitoring infrastructure, staffing, and research translation.
    - Consider partnerships with insurers and medical networks to support sample collection and analysis.

Conclusions

Despite decades of alarming incidents and growing scientific evidence of toxic exposure risks, the fire service still lacks a standardized, reliable post-exposure assessment system. This gap not only delays early detection and care but undermines firefighter trust and hampers preventative action. By establishing tiered guidelines, centralized infrastructure, and responsive communication protocols, agencies can transition from reactive to proactive health protection. Leadership, funding, and firefighter engagement are critical to finally breaking the cycle of study-without-action and ensuring long-term occupational health resilience.

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CAL/OSHA UPDATE ON WILDLAND/WUI RESPIRATORY PROTECTION

Dr. Mike Wilson

Summary

Dr. Mike Wilson provided a comprehensive overview of California's efforts to establish practical and enforceable respiratory protection regulations for firefighters operating in wildland and wildland-urban interface (WUI) environments. The presentation outlined the growing threat posed by toxic exposures during firefighting, the limitations in current respiratory protective equipment (RPE), and Cal/OSHA's participatory rulemaking process designed to address these critical issues in collaboration with key stakeholders.

Key Takeaways

1. **Urgent Need for Protection**: Firefighters face significant exposure to toxic and carcinogenic substances during WUI fires, yet current protections are inadequate.
2. **Evidence of Harm**:
   - International Agency for Research on Cancer (IARC) has classified firefighting as a Group 1 carcinogen.
   - Toxic chemicals from burning structures and vehicles increase cancer and health risks.
3. **Barrier to Innovation**:
   - The 2014 NIOSH report identified a lack of market demand as the primary reason manufacturers have not developed compliant respirators (e.g. there were not enough organizations willing to purchase compliant respirators).
   - Regulatory clarity is necessary to drive product innovation and availability.
4. **Regulatory Approach**:
   - Cal/OSHA proposes a standard requiring deployment of full-face, NIOSH-certified PAPRs within two years of market availability.
   - They are modeling rulemaking on community-based participatory research, integrating firefighter input at all stages.
5. **Field Testing Results**:
   - Initial testing of respirators showed some interference with operational tasks like hose handling and line cutting.
   - Concerns remain regarding cardiovascular strain, heat stress, and practical limitations during prolonged operations.
6. **Scientific and Regulatory Challenges**:
   - Current testing methods for filters don't account for real smoke conditions.
   - Regulatory barriers exist due to OSHA's IDLH (Immediately Dangerous to Life or Health) standards that may not reflect real-world exposures.
   - Complete certainty is not required

to act—Cal/OSHA advocates for action based on the balance of evidence.

Recommendations

1. **Advance Respiratory Standards**:
   - Finalize and implement a regulation requiring effective RPE tailored to specific firefighting tasks (e.g., PAPRs for structure protection, air purifying respirators [APRs] for hand crews).
2. **Stimulate Industry Innovation**:
   - Provide clear regulatory direction to encourage manufacturers to develop and market compliant equipment.
3. **Support Ongoing Research**:
   - Continue physiological testing and exposure assessment studies to address unanswered questions about respirator effectiveness and stress impacts.
4. **Implement Proactive Policies**:
   - Act on scientific suspicion and reasonable evidence of harm rather than waiting for definitive proof.
   - Calibrate standards of evidence based on severity and likelihood of harm.
5. **Enhance Stakeholder Collaboration**:
   - Maintain inclusive engagement with firefighters, unions, agencies, and manufacturers to ensure practical, field-ready solutions.

Conclusions

Cal/OSHA is charting a progressive, collaborative path toward firefighter health and safety by developing respiratory protection standards supported by scientific evidence, field testing, and community participation. This approach prioritizes proactive action in the face of increasing cancer risk and toxic exposure. While scientific and practical challenges remain, the agency's strategy is grounded in urgency, innovation, and respect for those on the front lines. The regulatory framework under development aims not just to protect but to transform industry standards and firefighter health outcomes across California and beyond.

THE WILDFIRE CONSERVANCY

FACILITATED DISCUSSION

Summary

The Q&A session following Mike Wilson's Cal/OSHA presentation revealed broad consensus on the urgent need for respiratory protection in wildland and wildland-urban interface (WUI) firefighting. However, the conversation also exposed the significant regulatory, technical, and cultural hurdles that need to be addressed. Participants discussed the impracticality of applying industrial respirator standards (IDLH, NIOSH) to the dynamic and hazardous environment of wildland firefighting. The session emphasized collaboration, practical testing, phased implementation, and regulatory flexibility as key strategies for progress.

Key Takeaways

1. **Regulatory Inflexibility**:
    - Current Occupational Safety and Health Administration (OSHA) and NIOSH standards, which treat environments as IDLH when exposure can't be quantified, create barriers to implementing practical respirator use.
    - Fire environments are too variable and chaotic to meet traditional industrial exposure assessment standards.
2. **NIOSH and NFPA Limitations**:
    - Manufacturers have not innovated due to restrictive NIOSH standards and lack of guaranteed markets.
    - NFPA 1984-compliant respirators are limited by rigid certification protocols unsuited for wildland contexts.
3. **Realities of Wildland Firefighting**:
    - Firefighters currently rely on ineffective solutions like bandanas and disposable N95 masks, which provide little to no protection and quickly degrade.
    - Even promising respirators often fail due to practical issues such as heat, sweat, communication interference, or discomfort during extreme physical exertion.
4. **Culture and Adoption**:
    - Firefighter buy-in requires training, understanding of limitations, and cultural integration of new protective equipment.
    - Historical resistance to SCBA use in structural firefighting is seen as a parallel; eventual normalization followed leadership and gradual integration.
5. **Phased, Iterative Implementation**:
    - Strong support emerged for controlled burn testing and pilot programs to identify unforeseen issues before wide-scale deployment.
    - A phase-in approach would allow feedback collection, data-driven refinement, and manufacturer iteration.
6. **Manufacturer Incentives**:
    - A competitive R&D initiative (similar to defense contracting) could incentivize innovation if the state

guarantees purchase agreements or future market potential.

7. **Funding and Flexibility**:
    - Concerns exist around who will pay for new respirators and how departments will integrate new gear without compromising existing PPE systems.
    - Regulatory flexibility will be essential to avoid backlash or noncompliance due to impractical mandates.

Recommendations

1. **Develop and Implement a Phased Regulation**:
    - Introduce a phased rollout starting with pilot use in controlled burns and lower-intensity operations (e.g., mop-up).
    - Reassess efficacy and usability within 12–18 months post-implementation and revise standards accordingly.
2. **Engage Firefighters in Design and Testing**:
    - Continue community-based participatory rulemaking.
    - Use firefighter feedback to drive design improvements and increase trust in new protective equipment.
3. **Push for NIOSH Flexibility or State Autonomy**:
    - Work with NIOSH to create firefighter-specific respirator criteria or seek state-level exemptions or standards.
4. **Incentivize Innovation Through Market Guarantees**:
    - Explore procurement guarantees or public-private partnerships to spur respirator development.
    - Consider funding pilot production through Cal/OSHA, CAL FIRE, or federal grants.
5. **Address Education and Cultural Integration**:
    - Develop training protocols, communication strategies, and leadership engagement plans to encourage acceptance and compliance.
    - Learn from SCBA adoption history—normalize new equipment through familiarity and incremental exposure.

Conclusions

The Q&A revealed shared frustration with the status quo and enthusiasm for change, grounded in the reality that firefighters remain woefully under protected from occupational exposures. There is broad consensus that the time for action is now, but also recognition that any solution must be iterative, realistic, and developed in close partnership with the fire service. Cal/OSHA's approach—centering collaboration, science, and flexibility—has been widely praised and should be the model going forward. This is not just a regulatory challenge; it is a cultural and public health imperative.

THE WILDFIRE CONSERVANCY

CAL/OSHA RULE MAKING FOR WILDLAND/WUI RESPIRATORY PROTECTION

Dr. Mike Wilson
Cal/OSHA

Summary

This in-depth session centered on the challenges and strategic path forward for Cal/OSHA's development of wildfire/WUI-specific respiratory protection regulations. Mike Wilson and participants discussed certification complexities, the limitations of current NIOSH and NFPA standards, the realities of wildland and WUI environments, and a harm-reduction approach to policy. The group emphasized the need for practical, flexible, and field-tested respiratory solutions, while also calling for pilot testing, regulatory adaptability, post-exposure follow-up, and a strong data foundation for long-term health monitoring and protection.

Key Takeaways

1. **NIOSH Certification Barriers**:
   - NIOSH certifies respirators for specific chemicals—not for wildland firefighting as a use-case.
   - Uncertainty about exposures in WUI environments makes it hard to meet certification criteria.
   - This forces default to SCBA in theory—impractical in wildland conditions.
2. **Need for a Pragmatic, Harm-Reduction Approach**:
   - Stakeholders advocate moving beyond binary "safe/unsafe" models to a continuum of improved protection.
   - Firefighters accept occupational risk but deserve meaningful mitigation tools (e.g., PAPRs over bandanas).
3. **Limitations of Current Standards**:
   - NFPA 1984 is seen as a good baseline but not the ceiling.
   - NFPA's rigid timelines and structures slow innovation; California may need to exceed federal guidance.
4. **Support for Pilot Programs and Phased Implementation**:
   - Strong consensus for controlled burn pilots to gather field data and refine PPE use protocols.
   - Pilot studies should focus on usability, physiological impact, and real-world performance.
   - Pilot projects can proceed independently of the full Cal-OSHA rulemaking process.
5. **Urgency of Action vs. Perfect Science**:
   - Participants reject the idea of waiting 10–15 years for full exposure characterization before acting.
   - Firefighters are currently operating in IDLH conditions with no protection—action is overdue.

6. **Device Options and Deployment Logistics**:
    - Mixed-use models and modular approach (PAPRs for engines, APRs for hand crews) are favored.
    - Considerations include battery life, filter durability, weight, training, and ease of use in the field. Logistical challenges of disposable parts (e.g. batteries, filter cartridges) are also a consideration, especially for remote or long deployments.
7. **Post-Exposure Tracking and Medical Follow-Up**:
    - There is no formal system tracking individual firefighter exposure histories.
    - Post-exposure health monitoring (e.g., cardiac events, stroke-like symptoms) is vital but currently rare.
8. **Administrative Controls and Leadership Buy-In**:
    - Fire officers and ICs should have flexibility to mandate or recommend respirator use.
    - Firefighter discretion is key, supported by cultural integration and practical training.
9. **Broader Applications and Multi-Purpose Use**:
    - PAPRs could also be used during mop-up, overhaul, hazmat, fire investigation, emergency medical systems (EMS) calls, and pump operations.
    - Encouraging multipurpose adoption increases utility and reduces cost justification barriers.

Recommendations

1. **Advance Regulation Based on Harm Reduction**:
    - Set NFPA 1984 as the starting point.
    - Allow Cal/OSHA flexibility to exceed it with a California-specific standard if warranted.
2. **Implement Phased Rollout with Pilots**:
    - Launch controlled burn studies to test usability, fit, filtration, and firefighter acceptance.
    - Gather physiological and exposure data (e.g., CO, PAHs, formaldehyde) to inform broader rollout.
3. **Develop Modular Respirator Strategy**:
    - Equip firefighters with task-appropriate devices (e.g., PAPRs on engines, APRs for field).
    - Consider dual-function systems (APR/PAPR capable) to extend utility.
4. **Build Exposure and Health Surveillance System**:
    - Track deployments, tasks, and exposures by individual firefighter.
    - Pair with medical follow-up for significant exposures and develop post-incident care guidelines.
5. **Integrate Administrative and Tactical Smoke Avoidance**:
    - Embed smoke exposure considerations into IC decision-making.
    - Train firefighters on behavioral techniques to reduce exposure (e.g., working upwind).
6. **Promote R&D and Innovation**:
    - Partner with manufacturers to drive innovation in sorbents and filter materials (e.g., metal organic framework fabrics [MOFs] for CO).

- Use California's market leadership to shape national standards and product development.

7. **Institutionalize Continuous Improvement**:

   - Include reopener clause in regulation for iterative updates.

   - Base future changes on emerging data and firefighter feedback.

Conclusions

Cal/OSHA's respiratory protection initiative is a critical and long-overdue effort to confront escalating health risks in wildland and WUI firefighting. Stakeholders broadly agree on the need for immediate, science-informed action that balances practicality, protection, and field realities. The adoption of a harm-reduction approach, coupled with phased pilots and continuous data collection, represents a realistic path forward. Ensuring firefighter safety isn't about eliminating risk—but giving them the best tools, knowledge, and systems to have a long and healthy career and retire with the expectation of many healthy life years.

THE WILDFIRE CONSERVANCY

ADVANCING PPE FOR THE FIRE SERVICE

Jeffrey Stull

Summary

This session led by PPE expert Jeff Stull explored the complex trade-offs in designing, selecting, and implementing personal protective equipment (PPE) for wildland and wildland-urban interface (WUI) firefighting. Key themes included the evolving needs of modern firefighting, the limitations of current standards, and the critical balance between protection, heat stress, mobility, contamination, and durability. Through interactive discussion and real-world examples, participants highlighted the pressing need for modular, practical, and evidence-based PPE solutions that consider not only performance, but also usability, logistics, and behavioral adoption.

Key Takeaways

1. **PPE Is a Trade-Off**:
    - Every gain in protection (thermal, particulate, chemical) comes at a cost—mobility, heat retention, communication, or comfort.
    - These trade-offs influence firefighter behavior, such as improper wear or avoidance of certain gear.
2. **Standards Are Outdated and Rigid**:
    - NFPA and OSHA standards often reinforce existing gear configurations and limit innovation.
    - Current testing focuses on individual fabric samples rather than evaluating PPE systems as ensembles.
3. **WUI Environments Demand New Solutions**:
    - Hybrid risks (e.g., structure fires in vegetative zones, battery fires) blur the line between wildland and structural needs.
    - Many departments lack WUI-specific gear and switch between structural and wildland gear depending on proximity and risk.
4. **Particulate Protection Is Promising but Problematic**:
    - New fabrics (e.g., DuPont's nanofiber) show >90% particulate blocking, but add weight and reduce breathability.
    - Field trials indicate psychological perceptions of heat and fabric "breathability" may not always match physiological data.
5. **Base Layers and System Design Matter**:
    - Proposals include tighter-fitting base layers with integrated barriers to reduce interface gaps and improve protection.
    - However, NFPA standards currently regulate only outer garments, leaving underlayers unregulated and inconsistent.
6. **Contamination Control Is Inadequate**:
    - Existing laundering methods remove only 50–70% of toxins; liquid carbon dioxide (CO_2) cleaning shows promise but is cost-prohibitive.
    - Barrier fabrics trap contaminants more effectively, but also off-gas heavily in apparatus cabs, increasing respiratory exposure.

7. **Durability vs. Cleanliness**:
    - Frequent washing to manage contamination reduces gear life from 7–8 years to 2–3 years.
    - This raises cost, logistical, and procurement challenges—especially for departments with limited resources or for firefighters that may contribute to their ensemble purchases and costs.
8. **Field Testing Is Essential**:
    - Psychological reactions to new gear (e.g., "it feels too hot") may not reflect physiological stress.
    - Ongoing CAL FIRE trials and planned field testing will help guide future PPE decisions.

Recommendations

1. **Redesign PPE from a Clean Slate**:
    - Consider function-specific, modular gear that accounts for mission type, duration, and environment.
    - Support development of garments that balance breathability, thermal protection, and particulate blocking.
2. **Revise Testing and Certification Standards**:
    - Shift from fabric-based testing to full ensemble/system testing under realistic conditions.
    - Advocate for flexible standards that allow innovation, pilot trials, and adaptive layering systems.
3. **Support Research Through Field Trials**:
    - Expand physiological monitoring (e.g., temperature sensors) during field tests of new PPE.
    - Compare subjective experiences with objective health indicators to validate perceived vs. actual impacts.
4. **Institutionalize Gear Maintenance and Cleaning**:
    - Explore regional or mobile CO_2 cleaning units for incidents and base camps.
    - Mandate routine cleaning policies and training to mitigate cross-contamination and off-gassing risks.
5. **Strengthen Regulatory Collaboration**:
    - Work with Cal/OSHA to maintain flexible variance procedures that enable PPE innovation without regulatory penalties.
    - Leverage CAL FIRE's market influence to shape national standards and drive manufacturing reform.
6. **Increase Awareness of Gear Lifespan**:
    - Train departments on gear aging, degradation, and minimum service life to avoid outdated PPE use.
    - Prioritize equitable funding for timely gear replacement and upgrade cycles.

Conclusions

This discussion laid bare the structural and scientific challenges facing PPE advancement in fire service today. While protective technology continues to improve, real-world implementation lags due to cost, policy rigidity, and cultural resistance. PPE reform must be multifaceted—balancing innovation with regulation, comfort with safety, and science with strategy. CAL FIRE's leadership in research, trials, and standard-setting offers a critical pathway forward. The future of firefighter health and safety hinges not just on better gear—but on smarter systems, holistic design, and sustained institutional commitment.

THE WILDFIRE CONSERVANCY

EVALUATING PPE FOR IMPROVING FIREFIGHTER HEALTH AND SAFETY

Dr. Bryan Ormond
North Carolina State University

Summary

Dr. Brian Ormand's presentation focused on advancing respiratory protection for wildland firefighters through rigorous laboratory and field testing. His team evaluated dozens of respiratory products (e.g., PAPRs, APRs, N95s, neck gaiters, and bandanas) for both filtration efficiency and breathing resistance using animatronic headforms, material-level testing, and prototype field studies. The project emphasizes developing realistic, scalable, and practical respiratory solutions that balance protection, usability, and operational feasibility. The work also explores new sorbent materials and future American Society for Testing and Materials (ASTM)standardization.

Key Takeaways

1. **Respiratory Protection Must Balance Filtration and Usability**:
   - High filtration often comes with increased breathing resistance.
   - Devices must be comfortable and practical for firefighters in high-heat, high-exertion environments.
2. **Traditional Testing Is Incomplete**:
   - Most existing standards are based on ideal lab conditions and do not reflect real-world or WUI scenarios.
   - Fit and filtration can drop significantly in the field due to sweat, movement, facial hair, etc.
3. **Varied Product Performance**:
   - N95s and PAPRs show highest lab filtration, but some neck gaiters perform surprisingly well (40–60% efficiency).
   - Bandanas and many cloth coverings offer minimal protection (~5–10%).
4. **Testing Methods Are Evolving**:
   - Use of animatronic headforms allows for more realistic simulations of breathing and movement.
   - Lab and field evaluations (including smoke exposure chambers and real fires) enhance accuracy and applicability.
5. **Human Trials and Realism**:
   - Planned field trials with CAL FIRE will simulate actual firefighting tasks and measure physiological and subjective responses.
   - Includes full PPE, temperature sensors, and pre/post questionnaires to evaluate comfort, breathability, and usability.
6. **New Technologies and Materials**:
   - Exploration of MOFs and other advanced sorbents to improve filtration, especially for gases like CO and formaldehyde.

- Opportunities to customize cartridges for wildland/WUI-specific exposures.

7. **Goal: Feasibility, Not Perfection**:
   - The project seeks to identify what's realistically usable and protective—not just what performs best under perfect conditions.
   - Focus is on incremental improvements and practical adoption over theoretical ideals.

Recommendations

1. **Develop Modular Respiratory Protection Options**:
   - Create task-appropriate gear (e.g., lightweight gaiters for mop-up, PAPRs for direct exposure) rather than a one-size-fits-all solution.
2. **Advance ASTM Testing Standards**:
   - Convert headform-based testing protocols into ASTM standards for consistent, reproducible evaluation of products beyond NIOSH certification.
3. **Prioritize Usability in Design**:
   - Incorporate user feedback on comfort, communication, heat, and breathability.
   - Test full ensembles, including interface between respirator and clothing.
4. **Conduct Comprehensive Field Trials**:
   - Implement trials with wildland firefighters to validate lab findings.
   - Evaluate operational challenges, thermal burden, and behavioral impacts of gear use.
5. **Push for Regulatory Flexibility and Guidance**:
   - Engage Cal/OSHA and NIOSH to support alternative protection levels (e.g., 60% filtration) for realistic firefighting conditions.
6. **Create Clear Recommendations for Manufacturers**:
   - Document effective design features, common failure points, and firefighter preferences to guide new product development.
7. **Expand Long-Term Exposure Monitoring**:
   - Use bio-monitoring and tracer analysis to evaluate real-world effectiveness of respiratory protection over fire seasons.

Conclusions

Dr. Ormand's research underscores the urgent need for firefighter-specific respiratory protection that is grounded in science, practicality, and user experience. Rather than seeking perfect solutions, the goal is incremental progress through rigorous testing and collaborative design. The research is leading the way toward standards and products that can protect wildland firefighters without hindering their performance. Upcoming field trials and policy engagement will be crucial to transforming this work into lasting institutional change.

THE WILDFIRE CONSERVANCY

STUDENT PRESENTATIONS: AIR CURTAIN PPE RESEARCH AND DEVELOPMENT FOR WILDLAND/WUI FIREFIGHTING

Alex Honn – *Boise State University*
Oliver Pilon – *Cal Poly San Luis Obispo*

Summary

Graduate students Alex Hahn (public health, Boise State) and Oliver Pilon (biomedical engineering, California Polytechnic San Louis Obispo) presented parallel but independently developed air curtain respiratory protection systems for wildland firefighters. Their designs aim to provide partial filtration and significant cooling benefits using modular, low-power units that integrate with existing PPE. While not yet compliant with NFPA or NIOSH standards, their approach prioritizes usability, heat stress reduction, and user autonomy—key limitations of current SCBA and disposable mask options in wildland settings.

Key Takeaways

1. **Innovative Air Curtain Design**:
   - Both presenters developed independently similar modular systems using air curtains to displace contaminated ambient air from the breathing zone.
   - Designs prioritize cooling, comfort, and partial filtration (40–80%) over-achieving full N95-level protection initially.
2. **Heat Stress Reduction as Primary Value**:
   - Delivering airflow over the head and neck significantly reduces heat stress, a major operational hazard.
   - This function also improves user acceptance and wear duration in the field.
3. **User-Centric, Modular, and Lightweight**:
   - Units use small fans powered by AA or AAA batteries for simplicity and field replaceability.
   - Designed to integrate with PPE like helmets and shrouds while allowing user control over fan and airflow zones.
4. **Low-Cost Prototypes, High Promise**:
   - Existing units show promising six-hour battery life and solid air displacement despite minimal funding and resources.
   - Prototypes emphasize quick connect/disconnect functionality and ease of use for firefighters in dynamic environments.
5. **Cultural Fit and Communication**:
   - Avoids the speech muffling and isolation issues of enclosed respirators.
   - Emphasizes behavioral adoption: firefighters choose when to use it, reducing stigma and improving compliance.
6. **Field Testing and Limitations Pending**:
   - Durability and real-world efficacy not yet validated; both teams plan field testing within the year.
   - No formal APF (assigned protection factor) data yet; research needed to quantify protection under various conditions.

7. **Filtration System Still Developing**:
    - Current filters combine existing particulate and volatile organic compounds (VOC) cartridges; not optimized for wildland toxins.
    - Future collaboration with manufacturers needed to refine filters for smoke-specific contaminants.
8. **Broader Applicability and Market Gaps**:
    - Design could extend beyond firefighting into construction, disaster response, and silica exposure environments.
    - Market skepticism and lack of commercial precedent hinder funding and development momentum.

Recommendations

1. **Advance to Field Trials Immediately**:
    - Secure funding and partnerships to test prototypes during controlled burns or low-risk operational periods.
    - Validate user feedback, durability, airflow effectiveness, and impact on heat stress.
2. **Formalize Protection Metrics**:
    - Develop a standardized testing protocol (e.g., animatronic headforms) to assess air curtain protection levels.
    - Quantify APF equivalents under varying environmental conditions.
3. **Refine for Regulatory Readiness**:
    - Align filter and housing designs to work toward eventual NFPA/NIOSH recognition or special exemptions.
    - Build toward California or Cal/OSHA pilot approvals to pave regulatory pathways.
4. **Improve Durability and Maintainability**:
    - Strengthen prototypes for rugged use; ensure modular parts can be quickly repaired or swapped in the field.
    - Design for fast battery replacement and filter changes with off-the-shelf parts.
5. **Invest in Collaborative R&D**:
    - Partner with engineers, manufacturers, and health researchers to enhance filter effectiveness.
    - Avoid duplicative work—create shared databases or consortia for PPE innovation.
6. **Market Strategically**:
    - Emphasize heat mitigation and user control as selling points rather than unmet respirator standards.
    - Pitch multipurpose applications across industries to expand support and viability.

Conclusions

The student-designed air curtain systems represent a promising leap in bridging public health and operational practicality for wildland firefighting. While not yet field-validated or regulatory-approved, their user-centered, modular approach solves real-world pain points—communication, heat stress, usability—that traditional respirators cannot. By reframing the device as a hybrid cooling/partial protection system rather than a strict "respirator," the teams offer a pathway for scalable, culturally appropriate harm reduction. With funding, collaboration, and pilot validation, these innovations could meaningfully reshape respiratory protection for a new generation of frontline responders.

THE WILDFIRE CONSERVANCY

FINAL THOUGHTS AND FACILITATED DISCUSSION

The final discussion of day two at the Symposium centered around firefighter behavioral health, the development of a new behavioral health Center of Excellence in California, and strategies for integrating behavioral wellness into the fire service at all levels. Participants reflected on personal experiences, shared current initiatives, and emphasized the urgent need for culturally competent support, proactive care, sustained research, and equitable access for both active and retired firefighters. A consistent theme was the need to institutionalize mental health support within firefighting culture and policy as comprehensively as physical protection.

Key Takeaways

1. **Behavioral Health is Critical and Underserved**:
    - Firefighters experience high rates of PTSD, addiction, depression, and suicide—often higher than the general population.
    - Peer support programs, if poorly implemented or lacking cultural competence, can backfire or be underutilized.
2. **Retirees and Dispatchers Are Overlooked**:
    - Retired personnel often lose access to support services post-career, despite carrying long-term psychological burdens.
    - Dispatchers face high levels of trauma exposure but are frequently excluded from mental health provisions.
3. **Stigma Still a Major Barrier**:
    - Firefighters hesitate to use mental health resources due to stigma, fear of reprisal, or perceived weakness.
    - Visibility and normalization (e.g., peer support, therapy dogs, casual interactions) are important to reduce stigma.
4. **Cultural and Clinical Competency Matter**:
    - Support must be led by individuals who understand the fire service culture.
    - Clinicians unfamiliar with first responder trauma often unintentionally give ineffective or even harmful advice.
5. **New Center of Excellence in California**:
    - A 300-acre facility in Riverside County is moving forward, with buildings for substance abuse, suicide prevention, and dedicated research.
    - The facility aims to incorporate sleep studies, duty-cycle research, and physiological monitoring tied to cancer and mental health.
6. **Research Gaps and Priorities**:
    - Need more firefighter-specific

studies on PTSD, sleep deprivation, cortisol levels, and long-term psychological effects.

- Post-incident support (especially for large-scale disasters) lacks structure and sustainability.
- Peer support teams themselves need ongoing support to manage the emotional toll of helping others.

7. **Education and Training**:
   - A mental and behavioral health course developed for a fire-specific bachelor's program at a California state university is a national first but needs support and expansion.
   - Calls for California to waive tuition for state firefighters taking such courses.
8. **Call for Coordination and a Clearinghouse**:
   - Repeated studies and siloed efforts waste time and resources.
   - Participants urged the creation of a centralized, accessible clearinghouse of firefighter wellness research and best practices.

Recommendations

1. **Establish and Fund the California Behavioral Health Center**:
   - Secure operational funding, ensure diverse service offerings (including for retirees and dispatchers), and prioritize research.
2. **Institutionalize Access for Retirees and Families**:
   - Amend policies to extend behavioral health benefits post-retirement.
   - Include family support in treatment plans due to their shared burden.
3. **Prioritize Clinically and Culturally Competent Care**:
   - Recruit and train clinicians specifically for the fire service.
   - Shift from general EAPs to peer-informed, fire-specific behavioral health models.
4. **Support National Standards and Educational Access**:
   - Mandate behavioral health education in training programs and academies.
   - Create tuition-free access to mental health courses for firefighters.
5. **Advance Research and Data Collection**:
   - Study long-term behavioral outcomes, PTSD progression, and impact of duty cycles on psychological health.
   - Include QR-code feedback tools post-incident to assess and improve mental health support effectiveness.
6. **Improve Incident Support Protocols**:
   - Strategically place peer support trailers, ensure privacy, and integrate behavioral teams into command structure.
   - Design recovery protocols for both operational and emotional fallout from incidents.
7. **Build a Comprehensive Clearinghouse**:
   - Compile ongoing research, best practices, and training materials into a single, accessible platform.
   - Promote cross-agency collaboration to eliminate redundancy and share innovations.

Conclusions

The final discussion underscored that firefighter behavioral health is a systemic issue, not a side project. The progress made in recent years—through peer support, cultural shifts, and dedicated centers—is substantial, but remains incomplete. Comprehensive support must include retirees, families, dispatchers, and large-incident responders. The California Center of Excellence is a promising model, but must be supported by policy changes, collaborative research, and cultural integration. The fire service's evolution depends not only on safer gear and cleaner cabs, but also on healing minds and sustaining mental resilience through every phase of a firefighter's journey.

THE WILDFIRE CONSERVANCY

PARTICIPATING ORGANIZATIONS

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Cal Department of Public Health

CAL FIRE

CAL FIRE Local 2881

Cal Poly San Louis Obispo

Cal/OSHA

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