

Research Article - fire & fuels management

The Impact of COVID-19 Prevention Measures on Interagency Hotshot Crews in 2020

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Abstract

In the 2020 fire season, the fire management community developed and tested a wide range of new practices to meet challenges posed by the coronavirus pandemic. To better understand the effectiveness of different innovations and which should be considered for more permanent use, we surveyed Interagency Hotshot Crew (IHC) superintendents in January 2021. We focused on identifying innovations that, regardless of COVID-19, the IHCs would want to keep and why, as well as those that proved problematic. The survey focused on paperwork, briefings, and fire camp and incident command post setup. Results found clear benefits from many of the changes to operational efficiency and crew health and wellbeing; challenges were generally tied to logistical and communication issues. The results of this survey speak to the logistics of running large incident command operations and could be applied both outside the US and outside the field of wildland fire management.

Study Implications: There may be meaningful benefits beyond mitigation of COVID-19 spread for continuing to use virtual paperwork, virtual briefings, and dispersed camp setups while supporting large fire suppression operations. Operational efficiency was seen as a clear benefit of many of these changes, with the often-mentioned advantage to a particular practice enabling crews to spend more time on the fireline. The new practices also appear to contribute to overall crew physical health. However, the benefits to crew health, efficiency, and effectiveness will need to be assessed against the increased logistical support required from incident management teams.

Keywords: wildland fire, operations, fire camp, survey, crews

In 2020, the wildland fire management system was faced with the critical question of how to safely and effectively suppress wildland fire while mitigating the spread of the highly contagious respiratory virus,

COVID-19 (Moore et al. 2020; Stoof et al. 2020). This was expected to be particularly challenging in the United States (US), where the response to a single large wildland fire may require the support of hundreds

to thousands of personnel who often work in conditions known to spread respiratory diseases (National Wildfire Coordinating Group 2010; Wildland Fire Lessons Learned Center 2020), and initial modeling indicated a high potential for COVID-19 outbreaks (Thompson, Bayham, and Belval 2020). This potential led the wildland fire community to initiate a range of new practices to mitigate potential spread of COVID-19 while working on large fires. Although developed in response to COVID-19, feedback over the course of the fire season suggested many of these new practices could be beneficial in years without pandemic concerns. Benefits of practices implemented in response to COVID-19 have been found in multiple fields such as healthcare and education (e.g., Arabi et al. 2021; Chen and Roldan 2021; Haslam 2021; Pettit et al. 2021; Stout et al. 2021; Li 2022; Poghosyan et al. 2022; Wood et al. 2022), although these benefits typically must be considered in tandem with the negative effects of the changes.

There has been little work speaking to the impact of incident fire management practices on firefighters working on the ground. Prior research examined communication between managers both during and before fire (Steelman et al. 2014; Nowell and Steelman 2015; Nowell et al. 2018), dispatching (Haight and Fried 2007; Ntamo et al. 2013; Wei et al. 2015, 2016; Belval et al. 2017, 2018; Bayham et al. 2020; Bayham and Yoder 2020), suppression costs (Calkin et al. 2005; Donovan 2005; Yoder and Gebert 2012; Hand, Thompson, and Calkin 2016), and fireline effectiveness (Katuwal, Calkin, and Hand 2016; Gannon et al. 2020), but none of the identified work speaks to the experience of crews on the ground. Research has been done on the health impacts of specific tasks and firefighter physical fitness (Sol et al. 2018; Gaskill et al. 2020; Marks et al. 2020; West et al. 2020), but this work speaks to impacts of firefighting tasks and general fitness rather than logistical management choices. The logistical impact on these crews is critical, as the efficiency and effectiveness of fireline tactics depend directly on the work done by these crews. Directly surveying those on the ground helps to identify logistical bottlenecks preventing crews from efficiency and practices they feel make them more effective and efficient at performing their job duties, as well as quantifying the impacts of these practices on crew wellbeing.

One critical group of federal firefighting personnel is the Interagency Hotshot Crews (IHCs), the most highly qualified type of firefighting crew in the US wildfire management system (National Interagency Hotshot

Steering Committee 2016; National Interagency Hotshot Crew Steering Committee 2019). Composed of 18 to 25 individuals, the crews (115 in existence in 2020) are provided primarily by the USDA Forest Service (91 crews in 2020), although some are hosted by agencies within the US Department of the Interior (21 crews) and state agencies (3 crews). These crews are used extensively during the US wildfire season (Belval et al. 2020); on average, each IHC spends 110 days each fire season on wildland fire assignments or related travel (2014–2019), generally for most of the summer and into the fall. Although there is some variation regarding the spatial nature of the assignments, the temporal patterns of IHCs nationally on assignments varies little between seasons. The 2020 season was fairly typical in this respect, with IHCs on assignment, on average, for 117 days. Therefore, the main changes in work environment experienced by the IHCs in 2020 were likely related to COVID-19 mitigation that affected large fire operations.

One place where much interpersonal contact traditionally takes place while wildland firefighters are on assignment is at the fire camp and the incident command post (ICP). The fire camp is where personnel gather after their shifts have been completed and they can get food, take showers, resupply, and rest (National Wildfire Coordinating Group 2022). The ICP is where the management of fire operations takes place, including the logistical administration of personnel (National Wildfire Coordinating Group 2022). Often co-located, fire camps and ICPs are places with potential for high levels of contact between large numbers of individuals (camps can serve over 1,000 personnel) from diverse contexts (e.g., firefighters, incident team members, contractors who provide food and camp supplies). Given their potential for high levels of interpersonal contact and COVID-19 transmission, many of the practices altered were tied directly to the structure and functions of the fire camp and ICP.

To assess whether any new practices developed to mitigate spread of COVID-19 were beneficial for future adoption by on-the-ground fire personnel, we surveyed superintendents of IHCs. In addition to operational benefits, questions were asked about health outcomes, as it had been shown that nonpharmaceutical interventions to mitigate COVID-19 also decreased spread of other diseases (Olsen et al. 2020, 2021; Feng et al. 2021) and fire camp has been known as a place where respiratory illness—often referred to as “camp crud”—spreads (National Wildfire Coordinating Group 2010, 2020). The results of this survey may provide insight

for the logistics of running large incident command operations and could be applied both outside the US and outside the field of wildland fire management.

Methods

Initial key informant interviews were done to identify which activities modified in response to COVID-19 affected firefighters the most. These interviews, as well as the combined expertise of the authors, revealed that fireline operations changed very little and the changes that affected firefighters were primarily logistical to minimize contact between personnel. Given their potential for high levels of interpersonal contact and COVID-19 transmission, many of the logistical changes identified by the authors and key informants were tied directly to the structure and functions of the fire camp and ICP. For example, checking in when arriving at the fire, checking out when leaving the fire, and reporting time are logistical functions that have traditionally been administered at the ICP. To minimize contact between personnel, fire managers experimented with having these paperwork tasks done virtually. Morning briefings are another activity traditionally done in person at the ICP. During these briefings, personnel stand or sit shoulder to shoulder in both indoor and outdoor settings as they are informed about the state of the fire and the strategy for the coming day. In 2020, managers experimented with both virtual and radio briefings to reduce contact that occurred during in-person briefings. In addition to experimenting with virtual paperwork and briefings to minimize interpersonal contact within the fire camp and ICP, several different models for more dispersed fire camps were tried.

The survey focused on four logistical areas identified by the authors and key informants as areas where impactful changes had been made: prefire preparations, virtual and remote paperwork and briefings, large fire camp organization, and COVID-19 procedures. We also asked more generally about crew wellbeing during the 2020 season. Because this article focuses on the new practices that are valuable regardless of the existence of COVID-19, we only report results from the following sections: virtual and remote paperwork and briefings, large fire camp organization, and general outcomes sections. General background information was also collected for the survey respondents, including their geographic area of origin, the geographic areas to which they were assigned, and the complexity level of the fires to which they responded in 2020 (i.e., number of fires to which they were assigned that were managed

by a Type 1, Type 2, or Type 3 Incident Management Organization¹). The specific survey questions can be found in the supplementary materials.

The survey was supported by both the Forest Service National Fire Crew Program Manager and the Assistant Director of Operations of the Fire and Aviation Management branch of the US Forest Service. The survey was developed in fall of 2020 and implemented in early 2021 using Survey Monkey. A link to the survey was emailed to nearly all (114 of 115) current IHC superintendents on January 11, 2021. The leader of each IHC, the superintendent, is an experienced and highly qualified wildfire professional who is both an active crew member and a manager with responsibility for the other personnel on the crew; as such, superintendents can provide a good perspective regarding both the personnel who build fireline on the ground and managers who are looking at the bigger picture. Email addresses for superintendents were provided by the Forest Service National Crew Program Manager. The solicitation email requested one response per crew and two follow up reminders were sent to those who had not yet responded. The survey remained open until Feb 23, 2021. We collected eighty-four usable responses (a 74% response rate). The responses to the questions on background information (home geographic area, assignment geographic areas, and complexity of fires to which crews were assigned) indicated that the characteristics of the respondent pool was similar to the general IHC population; there were no indications of potential nonresponse bias in regard to geographic location, IHC agency, or specific fire assignments.

Open-ended questions were initially coded with descriptive codes (e.g., sleep, meals). From these, five common themes were identified: operations, logistics, health and safety, communication, and management. The data was then recoded using these themes, as descriptive codes did not always map cleanly to a single theme. For example, problems with connectivity might be mentioned as a logistical need in one response but as a barrier to communication in another. The context surrounding the descriptive code drove the thematic recoding. Three individuals were involved in developing the descriptive codes and themes. Because the open-ended responses were short (most fewer than three sentences) and the contents straightforward, a single coder was used across the entire survey after the descriptive codes and themes were developed, with the coding being spot-checked by two others to ensure consistency. The coding was

done in ATLAS.ti Mac (Version 9.0.7) (Scientific Software Development GmbH 2021) and the results were then exported and analyzed using R (R Core Team 2019).

Some respondents only completed specific sections of the survey, so for many questions we report percentages based on the number of respondents who answered that particular question. The tables and supplementary materials show the exact number of respondents for each question, although the sample size is also provided within the text if it deviates from the total set of eighty-four respondents.

Results

Large Fire Operations: Virtual/Remote Paperwork and Briefings

Virtual Paperwork

The survey asked about three specific types of virtual paperwork: check-in, which is paperwork completed when firefighters arrive on a fire; demobilization, which is paperwork completed when firefighters leave a fire; and time tracking, which is how firefighters track their time to be paid. Responses showed a clear preference for using virtual paperwork, with a large majority indicating that all three classes of paperwork were

“Easier” or “Much easier” than procedures that had been used in the past (Table 1; 80%, 76%, and 76% respectively). This was paralleled by 75% of respondents indicating that virtual paperwork did not affect their crew’s ability to perform its duties efficiently or effectively (Table 2). However, 36% of respondents also said that they needed access to additional technology (e.g., temporary towers or satellite service, tablet with cellular) to effectively engage in virtual paperwork (Table 2).

Responses to open-ended comments regarding positive experiences with the three virtual processes (check in, demobilization, or time tracking) revolved around improved operational efficiency. The majority of the seventy-three people who provided information to one or more of the three open ended options indicated they found the virtual paperwork to be faster, more streamlined, more efficient or more effective than using and submitting hard copies, and forty respondents noted that ability to complete paperwork with a digital/email system expedited the process. A fair number also indicated the ability to complete paperwork while on the road was a plus, as was not going into camp and that not having to visit the camp/incident management post in-person provided for more operational time and/or time to get home or to another fire assignment.

When asked, “What made virtual check-in/demob/time tracking most challenging for your crew this year,” the most noted challenge across the three processes was communication issues related to technology such as connectivity issues. A lack of standardization across the system was also commonly noted as a challenge. At some fires, despite the virtual paperwork processes, respondents indicated they were still required to go to camp, often for specific signatures, which reduced the benefits of virtual paperwork.

Table 1. Responses to the close-ended questions, “How well did virtual check in/demob/time tracking work for your crew?” Results are presented as a percentage of the 79 respondents who answered each of these questions.

	Check-in	Time reports	Demob
About the same	11.4	13.9	13.9
Easier	79.7	75.9	75.9
More challenging	8.9	7.6	10.1
No response	0	2.6	0

Table 2. Responses to the close-ended questions, “Do you feel that using virtual paperwork affected your crew’s ability perform its duties efficiently or effectively?” and “Did you feel like you needed access to additional technology to effectively engage in virtual paperwork?” Results are presented as both a count and percentage of the 79 respondents who answered each question.

	Affected crew’s ability to do its duties efficiently or effectively		Needed access to additional technology to effectively engage in virtual paperwork	
	Count	Percent	Count	Percent
No	59	74.7	29	36.7
Yes	20	25.3	50	63.3
Total	79	100	79	100

Virtual Briefings

Responses to shifting morning briefings from in-person to virtual (either broadcast online or via radio) were also generally positive. The majority of respondents seemed to be comfortable with or prefer the increased use of virtual briefings (Table 3; 38% preferred virtual briefings and 33% had no preference). Although most respondents (Table 3; 54%) indicated the virtual briefings were as effective as in person, a larger portion felt they were less effective (29%) as opposed to more effective (17%). Very few felt virtual briefings cost time, with almost all respondents indicating virtual briefings either saved time (Table 3; 61%) or took about the same amount of time (35%).

Open-ended responses indicated that preferences and views of effectiveness revolved around efficiency of virtual briefings versus improved ability to communicate in person. Those who preferred or saw virtual briefings as more effective noted they were more operationally efficient by reducing drive times and increasing time on the fireline. Those who preferred

or found in-person briefings more effective highlighted better communication and ability to ask questions. Several of these responses noted that a virtual briefing works well for the incident-wide briefing, but that an in-person briefing is important at the division level.

Large Fire Operations: Fire Camp Organization

Most crews had the opportunity to try out different variations of fire camp and ICP organization and layout. We asked respondents to rank and indicate the main pros and cons, if any, for each of the following large fire camp setups, which were indicated during the key informant interviews to be the most common camp set-ups used in 2020:

- Traditional ICP
- Multiple moderate sized spike camps² with a smaller ICP
- Crew spikes on or near the line with full scale ICP
- Spike camps/ Forward Operating Base (FOB) in combination with a smaller ICP
- Other variation

Table 3. Responses to the close-ended questions, “Overall did your crew prefer virtual or in-person briefings?”, “Were the virtual briefings you received this summer as effective or less effective or more effective than in-person briefings?”, and “Did you find that virtual briefings saved or cost your crew time?” Results are presented as both a count and percentage of the 79 respondents who answered each question.

Overall did your crew prefer virtual or in-person briefings?		
	Count	Percent
Virtual	30	38
No preference	26	32.9
In-person	23	29.1
Total	79	100
Were the virtual briefings you received this summer as effective or less effective or more effective than in-person briefings?		
	Count	Percent
As effective	43	54.4
Less effective	23	29.1
More effective	13	16.5
Total	79	100
Did you find that virtual briefings saved or cost your crew time?		
	Count	Percent
Saved Time	48	60.8
Neither	28	35.4
Cost Time	3	3.8
Total	79	100

Although we did give respondents the option to rank an “other variation” and to tell us what that variation was, most respondents left that option blank and didn’t rank it or ranked it last. We therefore removed it from the analysis. Of the other responses that did have an option filled in, the main options were hotels, small spike camps, and self-sufficiency. Sixty respondents ranked all four of the predefined camp set-ups (see Figure 1 for the aggregate results).

Survey respondents clearly preferred layouts other than the traditional single large fire camp and associated ICP, with 73% of respondents ranking that setup as their fourth choice. The most favored option was crew spikes on or near the line with full-scale ICP camp away from the fire, with almost half (48%) ranking it as their first choice and only 2% ranking it as their fourth choice. The second preferred option was the FOB combo with small ICP, with 32% ranking it first and 38% of respondents ranking it as second choice. Multiple spike camps with small ICP was overall the third-ranked option, with the majority ranking it as either their second (30%) or third choice (45%).

To understand possible reasons why different camp types might be preferred, we asked respondents to list the pros and cons of each camp type. We considered all responses here, even those who did not rank all four predefined camp setups; percentages listed reflect the population who specifically commented on a pro or con of that camp setup. Reflecting their rankings, respondents provided a wider range of pros than cons for crews spiking on the line with a full scale ICP. When speaking to the pros of this camp type respondent comments ($n = 63$) focused on health and safety (65%), logistics (52%), and operations (37%).

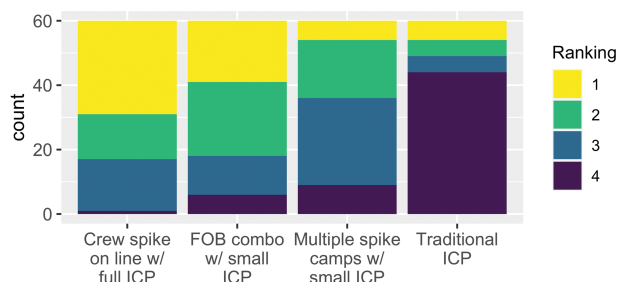


Figure 1. The count of respondents that gave each of the predefined camp setups a rank of 1, 2, 3, or 4. The four predefined camp setups were traditional incident command post (ICP), multiple moderate-sized spike camps with a smaller ICP, crew spikes on or near the line with full-scale ICP and forward operating base (FOB)/ spike camp combination with a smaller ICP.

The main comment around health and safety was that it enabled better sleep, with a number of respondents also noting that there was less exposure. The primary logistical benefit was that there was less driving, which was sometimes then directly tied to better operational efficiency as it enabled more time on the line. A number of respondents simply said that the setup made it easier for them to accomplish more operationally.

“More efficient, less travel time, better rest.”

“Accomplish more with better sleep.”

“Ideal for most effective line production. Easier to take advantage of time of day (get more done early when its cool).”

The main cons respondents provided ($n = 58$) were around logistical issues (74%) with general logistical support and decreased meal quality being the most commonly mentioned issues.

Fewer overall pros and cons were provided for the FOB in combination with a small ICP. However, similar themes emerged with respondents describing pros ($n = 52$) mainly around logistics (48%), health and safety (38%), and operations (23%), with less driving also the most commonly mentioned logistical benefit and better sleep and less exposure the primary health and safety benefits. For this camp option, the positive logistical comments were not focused only on less driving but also on better logistical support. However, of the respondents describing cons ($n = 43$), logistical issues were also the most commonly mentioned negative (46%) with comments generally centering around facilities, resource issues and meal issues.

Similar to the FOB in combination with a small ICP, responses about the pros of the multiple moderate-sized spike camps with a small ICP ($n = 59$) had the most comments around logistics (66%) followed by health and safety (47%) and operations (14%). The main logistical pro was less driving, but a fair number of comments for this option also were made about better logistical support and supply improvement. For health and safety, roughly equal numbers mentioned that the option enabled better sleep, was less crowded, or had less exposure. This option had an almost equal number of con comments ($n = 54$) and pros for logistical (63%) and health and safety (37%) issues. The most commonly mentioned cons were comments about food and facility issues, noise, sleep, crowd, and increased exposure associated with the moderately sized spike camp.

When evaluating the pros and cons of the traditional ICP, respondents provided roughly the same number of pros and cons. Perhaps unsurprisingly, responses were in many ways the inverse of the spike camp pros and cons. For the traditional camp, the pros mentioned ($n = 63$) focused mainly around logistics (75%)—primarily the central access to supplies and support and improved meals—and communication (25%)—primarily around the improved ability to access communication and to communicate with others.

“Everything is in one place, supplies are generally available, easy access to food.”

“Warm food and more food. Better access to supplies”

“Opportunity for robust in person meetings with GIS capability. Coordination with medical and operations in the same place, along with the communications shop for yellow/red medicals. Logistics ease.”

The cons mentioned ($n = 64$) were mainly around health and safety (72%) and logistics (69%). For health and safety, respondents described increased sickness and unsanitary conditions—often referencing camp crud as well as COVID-19—and sleep and noise issues. The primary logistics issues were related to crowded conditions and excess driving.

“Sickness spreads and time is wasted.”

“Crowded, parking, dirty (Human dirt, not the natural stuff)”

“Lack of quiet sleeping area, vector for camp crud/coronavirus, driving time and exposure.”

General Outcomes

Finally, to understand how crews viewed the overall impacts of the changes, we asked participants to indicate whether the changes implemented over course of the 2020 season positively or negatively affected (1) crew efficiency or effectiveness in performing fire suppression operations, (2) crew members' physical health, and (3) crew members' mental health in 2020 compared with previous fire seasons (Table 4). For each of these questions, we also asked superintendents to note which practices had the largest impact and why.

The majority of those responding ($n = 68$) said that overall, the changes to practices in 2020 had a positive effect on crew efficiency or effectiveness (65%) whereas 28% said there was no effect and 7% indicated that the changes had a negative impact. Open-ended responses indicated that increased crew efficiency was

Table 4. Responses to the close-ended questions “Do you feel any of the various changes positively or negatively affected crew efficiency or effectiveness in performing fire suppression operations?”; “How do you feel that your crew members physical health was this season compared to previous fire seasons?”; and “How do you feel that your crew members mental health was this season compared to previous fire seasons?” Results are presented as both a count and percentage of the 68 respondents who answered the question.

Do you feel any of the various changes positively or negatively affected crew efficiency or effectiveness in performing fire suppression operations?		
	Count	Percent
Negatively	5	7.4
Neither	19	27.9
Positively	44	64.7
Total	68	100
How do you feel that your crew members physical health was this season compared to previous fire seasons?		
	Count	Percent
Healthier	50	73.5
No Change	15	22.1
Less Healthy	3	4.4
Total	68	100
How do you feel that your crew members mental health was this season compared to previous fire seasons?		
	Count	Percent
No Change	30	44.1
Less Healthy	22	32.4
Healthier	16	23.5
Total	68	100

roughly equally attributed to practices that improved crew health and those that improved operational efficiency from increased operational time, virtual paperwork, and spending less time at camp and being closer to the fireline.

Responses were similar in relation to views of crew member physical health when compared with previous seasons ($n = 68$) with 74% indicating their crew members were physically healthier than previous seasons, 22% indicating there was no change, and only 4% believing that their crew members were less physically healthy. In the open-ended comments ($n = 55$),

respondents noted that less sickness overall was a large part of improved health, with specific comments about reduced interactions with others, improved hygiene and sanitation, and better sleep.

Although it might be expected that locating spike camps away from smoke also might be a reason for improved health outcomes, given the relationship found between smoke exposure and increased susceptibility to COVID-19 (Henderson 2020), this does not appear to have been a major dynamic. The vast majority of responses (58 of 71) to a question focusing on smoke mitigation indicated their crew did not change smoke mitigation techniques in 2020 with many noting: “mitigated smoke exposure like we always do.” Of the 13 respondents who did change their mitigation actions, eight directly cited the ability to choose where to sleep rather than being required to be in a large camp as being beneficial to mitigating smoke exposure. In addition, in response to the open-ended question “which practices used this year (up to 3) had the most effect on physical health of your crew and how/why”, only two respondents explicitly noted lessened smoke exposure as contributing to better health.

Although superintendents generally agreed the new practices had an overall positive effect on both crew efficiency or effectiveness and physical health in 2020 than previous seasons, there was less consensus regarding the state of crew members’ mental health. The largest share of respondents indicated that overall crew member’s mental health was unchanged (44%, $n = 68$), whereas 32% indicated that mental health suffered in 2020, and 24% indicated that mental health improved. Open-ended comments ($n = 37$) provide insight into the reason for the split results. The superintendents who found the crew members’ mental health improved cited better sleep and higher morale as the reasons mental health improved.

“As a team it was healthier. We spent more time with each other and provided each other with more support.”

“More rest Better rest Spiking out generally lifts the spirits anyways.”

Those who found that mental health suffered cited general crew member stress and anxiety, particularly around COVID-19 concerns, challenges with logistics, and social concerns (i.e., limitations in ability to socialize with other firefighters or family and friends at home and crew cohesion) as the reasons for the decrease in mental health.

“Added stress and anxiety over Covid was expressed to me. Lack of socialization with family and friends outside of crew had impact on people’s mental health.”

“I feel like they were taxed more due to lack of social interaction both in and out of work.”

“I felt the mental health of our crewmember was a little less healthy as we were constantly under stress of possible exposure to the virus. We come from a Native American community where the stress of not getting the virus is very important as many elderly and numerous tribal members who are on the high risk lives may be threatened if we may have been the carriers and caused illness or possibly death. Extra precaution was taken before we returned to our home unit.”

Desired Changes

We asked several open-ended questions about practices respondents would like to keep or abolish. We asked three separate questions regarding practices that could be implemented immediately ($n = 63$), immediately provided additional support ($n = 47$), and eventually with substantial support ($n = 30$); responses were fairly consistent across the three levels. Reflecting the positive responses to virtual paperwork and briefing sections, keeping virtual processes in place was mentioned by 42 individual respondents across all three implementation levels. Continuing to keep some of the altered camp and ICP organizational structures was also popular, with 39 people including it in at least one of their responses.

We received substantially fewer responses to similar questions asking about practices that respondents would like to see abolished ($n = 37$) and no themes emerged in the practices mentioned by respondents. The most common response was that there was nothing they would like to see abolished (ten). Four respondents noted they’d like to see changes to meals or food, and three responded that they would like to do away with unnecessary health protocols.

Respondents did note challenges with some of the health protocols that were implemented in response to COVID-19. 12 of 39 respondents who answered the question “Is there anything that you tried at the beginning of this year that seemed like a good idea, but ended up being problematic?” noted health protocols that didn’t work out. For example, one person said,

“Daily COVID screening questionnaire. After a few weeks together everyone understood the importance of just letting someone know if they weren’t

feeling well. We just stopped doing it after the first couple of weeks and let the adults that we employ act as adults."

Discussion

Although the changes required to combat the COVID-19 pandemic added complexity to a busy fire season in 2020, the survey results indicate many of the changes improved IHC operational efficiency and wellbeing. These results are important for fire managers to consider as they decide what practices to support in the future. As fire managers adjust to the ongoing presence of COVID-19, it may seem simplest to just return to pre-pandemic practices, including use of the traditional ICP fire camp design. However, our results indicate there are meaningful benefits beyond mitigation of COVID-19 spread to continuing using many practices developed in 2020.

Operational efficiency was a clear benefit of many of the changes, with an often-mentioned advantage to enabling crews to spend more time on the fireline. Virtual practices allowed crews to do paperwork while on the road and reduce their time going to and waiting at an ICP to complete the check-in and demobilization processes. Remote briefings were identified by IHC superintendents as more efficient than in-person briefings as they reduced the time crews spent driving and increased the time they could work on the fireline. Dispersed camp options that allowed crews to spike on the fireline were identified by hotshot crews as more operationally efficient than the traditional fire camp for the same reasons. It is important to note that other personnel working to manage large fires (e.g., members of incident management teams) may have a substantially different view of these practices, and it would be important to understand perspectives of a range of incident response personnel to fully understand the pros and cons of any new practice.

In addition to improving operational efficiency, the new practices also appear to contribute to a crew's overall physical health. Respondents identified two primary mechanisms that improved physical health: (1) reduced contact with others resulting in fewer contagious illnesses and (2) better sleep resulting in less fatigue, leading to generally improved physical fitness. The virtual paperwork processes, remote briefing procedures, and dispersed camping arrangements that removed requirements to physically visit the ICP were all credited with a reduction in contact with other people. Better sleep was primarily noted as a function of

alternative fire camp and ICP setups. The improvement in physical health regarding sleep is particularly notable given that fatigue management is a well-known issue faced by firefighters (Vincent et al. 2018); IHCs work 16-hour days for 14-day assignments and noisy, well-lit camps can pose a significant challenge to getting high-quality sleep. Thus, changes to fire management practices that improved sleep quality were seen as highly valuable from the crews' perspective.

Although the changes were seen by hotshot crews to have clear benefits regarding operational efficiency and physical health, there were also some challenges associated with the new practices. The negative aspects identified by survey respondents generally related to a lack of logistical support and challenges in communication. A number of these issues were likely a byproduct of the rapid implementation of the new practices in response to the pandemic and could likely be mitigated with a longer planning timeline. For example, although meal quality was an often-mentioned negative, several respondents also noted improvements in meals over the course of the 2020 fire season as solutions were found that could be more broadly applied. Some of the communication and connectivity issues could similarly be addressed with additional effort in setting up mobile cell towers and providing crews with additional devices (i.e., tablets). However, it is important to note that the logistical support required for dispersed camps will likely always be higher than for a centralized camp. The tradeoffs between this additional logistical support and the additional operational efficiency gained from dispersed camps is something decision makers may want to consider as fire practices evolve.

Given expectations that the frequency of large fires burning simultaneously across the country will increase (Abatzoglou et al. 2021) coupled with a shrinking federal firefighting workforce (Wildland Firefighting Workforce Reforms 2021), maximizing the operational efficiency of firefighting personnel whenever possible will be increasingly important when planning for future US fire seasons. In addition, improving working conditions for firefighters on the ground is a critical workforce management concern, particularly as retention of firefighters is challenging public agencies. The survey results provide important insights on these issues. Additionally, as global wildland fire occurrence increases due to climate change (United Nations Environment Programme 2022), the survey results presented here may provide important insights for wildfire management outside the US.

Supplementary Materials

Supplementary data are available at *Journal of Forestry* online.

Supplement 1. A csv file containing the results of a survey of Interagency Hotshot Crew (IHC) superintendents administered in January 2021. The survey focused on paperwork, briefings, fire camp and incident command post setup. To facilitate use of the csv file format, commas were removed from the content and, if needed for clarity, replaced by “or” or “and.”

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End Notes

1. In the US, the largest scale, most highly complex fires requiring national and regional coordination, are managed by a Type 1 or Type 2 Incident Management Team. Extended fires requiring regional or local coordination are often managed by Type 3 teams.
2. “Spike camp” refers to camping away from the larger fire camp and is a practice that tends to be used for assignments where coming back to camp would take substantial time and effort.

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Sample population section

Overall number
respondents who
completed at least
part of this section 84

Hosting Geographic Area (GA)

GA Name	Count	Percent
Southern California	14	16.7
Southwest	14	16.7
Northern California	13	15.5
Northwest	9	10.7
Great Basin	8	9.5
Rocky Mountain	7	8.3
Northern Rockies	6	7.1
NA	5	6
Alaska	3	3.6
Southern Area	3	3.6
Eastern Area	2	2.4
total	84	100

How many of each type of fire did you go to? (percent)

	0 fires	1-4 fires	5-10 fires	11+ fires	NA	
Type 1	11.9	66.7	20.2	1.2	0	
Type 2	3.6	82.1	14.3	0	0	
Type 3	6	51.2	38.1	0	4.8	

Virtual paperwork section

Overall number
respondents who
completed at least
part of this section 79

How well did virtual check in/demob/time tracking work for your crew? (percent)

number respondents 79 for all three questions

	Check in	Time reports	Demob
About the same	11.4	13.9	13.9
Easier	79.7	75.9	75.9
More challenging	8.9	7.6	10.1
NA	0	2.6	0

What made virtual check-in/demob/tracking most efficient? (count of respondents that mentioned each specific category or theme)

	Check in	Demob	Time tracking	All comments combined (no double counting so if a respondent noted it in more than one response it only counted once)
total number responses	73	71	71	73
<u>Descriptive codes:</u>				
More streamlined / efficient/ easier / faster	35	38	31	65
Digital/Technology benefits	13	25	22	40
Other	10	18	14	33
Reduced interpersonal contact	6	9	10	22
More operational time/get home/to another assignment	17	2	0	18
No need to visit camp (operationally efficient)	10	0	0	10
Better intel/ documentation	2	0	8	9
Connectivity	7	5	0	9
Variation across teams/season	4	2	0	6
Less waste	0	0	2	2
Overhead / management	0	2	0	2
Less efficient	1	0	0	1
<u>Themes:</u>				
Operational Efficiency	50	40	39	71
Connectivity	21	28	22	43
Health and Safety	6	9	12	24

What made virtual check-in/demob/tracking time most challenging for your crew this year?

All comments combined (no double counting so if a respondent noted it in more than one response it only counted once)

	Check in	Demob	Time tracking	
total number responses	69	71	67	75
<u>Descriptive codes:</u>				
Adjustment period	4	0	0	4
Communication issues	0	15	4	17
Connectivity issues	17	8	22	34
Did not use	0	0	3	3
Lack of face to face communication	5	0	0	5
Lack of standardization	14	12	8	30
Less efficient	4	0	0	4
Less efficient operations	0	4	0	4
Logistics	0	0	0	17
Management issues	3	17	7	13
Not challenging	14	6	14	26
Organization of documents	0	21	5	5
Other	8	8	0	16
QR Codes	1	0	0	1
Slow/ Technical difficulties	0	7	0	7
Still having to go to camp (management)	0	0	6	6
Still having to go to camp (ops)	3	7	0	10
Technology issues (connectivity)	10	0	14	20
<u>Themes:</u>				
Communication	14	15	4	27
Logistics	32	24	36	56
Management	15	17	18	36
Operations	0	17	0	17

Do you feel that using virtual paperwork affected your crew's ability perform its duties efficiently or effectively? If Yes please briefly explain.

	Count	Percent
No	59	74.7
Yes	20	25.3
Total	79	100

number open ended
resonances

21

Descriptive codes: Count

More operational time: efficiency	8
Other	8
Logistics	4
Streamlined process: Efficiency	4
Yes: Efficiency	3

Themes:

Operations	13
Logistics	4
Communication	1

Did you feel like you needed access to additional technology to effectively engage in virtual paperwork? If Yes please briefly explain.

	count	percent
Yes	29	36.7
No	50	63.3
Total	79	100

number open ended
responses

30

Descriptive codes: Count

Service/ connectivity (tower/satellite)	14
Tablet with Cellular (e.g. ipad)	8
other	5
pdf scanner/ doc organizer	3
improved eforms	1

Themes:

Logistics	24
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Briefings section

Overall number
respondents who
completed at least
part of this section 79

Overall did your crew prefer virtual or in-person briefings? Please briefly explain your response.

	count	percent
Virtual	30	38
No preference	26	32.9
In-person	23	29.1
total	79	100

number open ended
responses 56

Descriptive codes: Count

Combination would be best	17
other	16

Preferred in person for communication/ engagement	11
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Preferred virtual less unnecessary interaction	7
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Preferred virtual more efficient	7
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Preferred in person	3
Preferred virtual less driving	3

Preferred in person for improved problem solving	1
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Never did virtual	1
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Themes:

Communication	32
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Health and Safety	7
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Operations	7
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Logistics	3
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Were the virtual briefings you received this summer as effective or less effective or more effective than in-person briefings? If less effective or more effective please explain briefly.

	count	percent
As effective	43	54.4
Less effective	23	29.1
More effective	13	16.5
total	79	100

number open ended
responses 41

Descriptive codes: Count

Less Effective: worse for questions or communication or problems	15
More effective due to efficiency	10
other	4
More effective due to logistics	3
neither: they are the same	3
Combination is best	2
Depends on mission	1
Less effective: redundant	1
<u>Themes:</u>	
Communication	17
Operations	12
Logistics	3

What do you find to be the most beneficial aspect of virtual briefings?

number responses 76

<u>Descriptive codes:</u>	Count
faster	25
Reduced interaction	21
Less driving	14
Less time at camp	12
improved communication	11
Easy to access and share content	10
More operational time	10
Able to be close to work/line	6
more sleep	5
nothing	4
other	1

Themes:

Operations	34
Logistics	24
Health and Safety	23
Communication	19

What do you find to be the most challenging aspect of virtual briefings?

number responses 68

<u>Descriptive codes:</u>	Count
communication	28
Connectivity	15
other	11

Technical difficulties	11
nothing	10
feeling engaged/ connected	7

Difficulty asking questions/ clarifying	3
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Themes:

Communication	33
Logistics	24

What are the minimum requirements needed for an effective virtual briefing?

number responses 69

Descriptive codes: Count

communication
info/needs 35
operations info 32

environmental info 19
logistics info 16
other 9

Themes:

Operations 36
Communication 35
Logistics 16

Did you find that virtual briefings saved or cost your crew time? If Saved time or Cost time on average how many minutes for IHC leadership? If Saved time or Cost time on average how many minutes for other crew members?

	count	percent
Saved Time	48	60.8
Neither	28	35.4
Cost Time	3	3.8
total	0	100

Large fire camp section

Overall number
respondents who
ranked at least one
camp set up 70

Ranking the alternative camp set ups

COUNTS

	ranked 1	ranked 2	ranked 3	ranked 4	ranked 5	not ranked
Crew spikes on or near the line with full scale ICP	25	18	14	5	3	5
Spike camps/ Forward Operating Base (FOB) combo with a smaller ICP	17	21	15	8	5	4
Multiple moderate sized spike camps with a smaller ICP	7	15	27	12	5	4
Traditional ICP	6	7	4	25	22	6
Other variation (Describe camp set up)	7	2	3	15	26	17

PERCENT (out of 70 responses)

	ranked 1	ranked 2	ranked 3	ranked 4	ranked 5	not ranked
Crew spikes on or near the line with full scale ICP	35.7	25.7	20	7.1	4.3	7.1
Spike camps/ Forward Operating Base (FOB) combo with a smaller ICP	24.3	30	21.4	11.4	7.1	5.7
Multiple moderate sized spike camps with a smaller ICP	10	21.4	38.6	17.1	7.1	5.7
Traditional ICP	8.6	10	5.7	35.7	31.4	8.6
Other variation (Describe camp set up)	10	2.9	4.3	21.4	37.1	24.3

number respondents
 who ranked all four
 predefined camps 60

Ranking the alternative camp set ups (only those who ranked all four pre-defined camp set ups: adjusted to remove the Other ranking)

COUNTS

	ranked 1	ranked 2	ranked 3	ranked 4	
Crew spikes on or near the line with full scale ICP	29	14	16	1	60
Spike camps/ Forward Operating Base (FOB) combo with a smaller ICP	19	23	12	6	60
Multiple moderate sized spike camps with a smaller ICP	6	18	27	9	60
Traditional ICP	6	5	5	44	60

PERCENT (out of 60 responses)

	ranked 1	ranked 2	ranked 3	ranked 4	
Crew spikes on or near the line with full scale ICP	48.3	23.3	26.7	1.7	
Spike camps/ Forward Operating Base (FOB) combo with a smaller ICP	31.7	38.3	20	10	
Multiple moderate sized spike camps with a smaller ICP	10	30	45	15	
Traditional ICP	10	8.3	8.3	73.3	

Indicate the main pros and cons if any for each of the following large fire camp set-ups:

Crew spikes on or near the line with full scale ICP

	Pros	Cons
number responses	63	58
<u>Descriptive codes:</u>		
Better Sleep	34	
Less driving	24	
Accomplish more	19	
Less exposure	16	
Other	12	5
Logistics	8	35
More Efficient	6	
Meals	4	14
None	3	
Improved morale	2	
Crowded/traffic		4
Connectivity		3
Facilities		3
Medical support		2
Relationships		2
<u>Themes:</u>		
Health and Safety	41	
Logistics	33	43
Operations	23	

Spike camps/ Forward Operating Base (FOB) combo with a smaller ICP

	Pro	Con
number responses	52	43
<u>Descriptive codes:</u>		
Less Driving/closer to line	16	
Logistics	14	13
Better sleep / sleep issues	13	
Other	10	9
best/better option	9	
Less Sickness/ interaction	8	
Less crowded	4	
Accomplish more	3	
Communication	2	4
None		8
Facilities/ Resources		
Issues		7
Meal issues		6
Crowded		4
Connectivity issues		1
<u>Themes:</u>		
Logistics	25	24
Health and Safety	20	
Operations	12	
Communication	2	4

Multiple moderate sized spike camps with a smaller ICP

	Pro	Con
number responses	59	54

Descriptive codes:

Less Driving/ Closer Logistics/ Supply improvements	27	
Less Crowded	18	
Sleep issues	13	4
Interaction/ exposure	12	
More Efficient	8	9
Other	8	
Logistical/ Resource Issues	6	1
Management issues		27
None		7
Facilities lacking		6
Food issues		6
Connectivity		4
Crowded		4
Noisy		3
Waste issues		2
Travel time		1

Themes:

Logistics	39	34
Health and Safety	28	20
Operations	8	
Management		7

Traditional ICP

	Pro	Con	
number responses	63		64
<u>Descriptive codes:</u>			
Central access to supplies/support	41		
Communication improvements	16		
Meals	14		1
Logistics	8		5
Other	6		8
Facilities/amenities	4		
Improved planning/ops	4		
Familiarity/ easy to understand	3		
Connectivity improvements	2		
none	2		
Sickness/unsanitary			40
Crowded			32
Sleeping issues			17
Noise issues			15
Excess driving/distance from fire			14
Delays/inefficient parking issues			12
			4
<u>Themes</u>			
Logistics	47		44
Communication	16		
Operations	4		12
health and safety			46

Other variation (Describe camp set up)

	Pro	Con
number responses	13	10

Camp type described: Count

Hotels	3
Self-sufficient	2
Small spike camps	2
Other	1

Pro	Con
-----	-----

Descriptive codes:

Better Sleep	4	
Less Exposure	4	
Logistics	3	5
None		4

Themes:

Health and Safety	5	
Logistics	5	5

General outcomes section

Number of
respondents who
answered at least one
question 68

Do you feel any of the various changes positively or negatively affected crew efficiency or effectiveness in performing fire suppression operations? If Positively or Negatively please briefly explain which changes (up to 3) had the most effect and how/why.

	Count	Percent
Negatively	5	7.4
Neither	19	27.9
Positively	44	64.7
Total	68	100

number open ended
responses 50

Count

Descriptive codes:

Positive: Health improvements	27
Positive: Logistics improvements	15
Positive: More operational time	14
Positive: Efficiency from Virtual pw	11
Positive: Less time at camp	10
Positive: Reduced exposure	10
Negative: other	9
Positive: Closer to the line/fire	6
Negative: relationships issues	5
Negative: resource shortages	3
positive: other	3
Negative: increased exposure	2

Themes:

Health and safety	32
Operational efficiency	30
Logistics	23

**How do you feel that your crewmembers physical health was this season compared to previous fire seasons?
If Healthier or Less Healthy please briefly explain which practices used this year (up to 3) had the most effect**

	Count	Percent
Healthier	50	73.5
No Change	15	22.1
Less Healthy	3	4.4
Total	68	100

number open ended
responses 55

Descriptive codes:	Count
Healthier: Less sickness	24
Healthier: reduced interaction	20
Healthier: Improved hygiene or sanitation	15
Healthier: Better sleep	13
Healthier: Less time in camps	11
Healthier: Better Food	9
Healthier: other	9
Less Healthy: Insufficient food	3
Less Healthy: No gyms	3
Less Healthy: other	2

Less Healthy: Sedentary Quarantine	2
Themes:	
Health and Safety	49
Healthier All	49
Less Healthy All	6
Logistics	5

How do you feel that your crewmembers mental health was this season compared to previous fire seasons? If Healthier or Less Healthy please briefly explain which changes this year (up to 3) had the most effect on the mental health of your crew and how/why.

	Count	Percent
No Change	30	44.1
Less Healthy	22	32.4
Healthier	16	23.5
Total	68	100

number open ended
responses 37

Descriptive codes: Count

Covid	16
More Stress	15
Logistics	12
other	12
Social Concerns	9
Better sleep	8
Higher Morale	4

Themes:

Health and Safety	35
Logistics	12

Changes to keep or abolish section

Number of
respondents who
answered at least one
question

67

If and when COVID-19 is no longer a health threat what practices developed this summer would you want to keep and why? For each please indicate could be implemented: 1) immediately 2) immediately provided some additional support (i.e. national level support or forest level support or additional funding) 3) eventually with substantial additional support but would be worth the investment? Please list up to 3 for each level.

Could be implemented:

	immediately			
eventually with	provided			
substantial	additional			
support	support	immediately		All comments combined (no double counting so if a respondent noted it in more than one response it only counted once)

number of responses	30	47	63	
<u>Descriptive codes:</u>				
virtual processes	3	12	31	42
Camp set up or				
lodging	5	11	27	39
Food/meals	4	13	12	28
other	6	10	5	17
logistics		8	2	10
Vehicles	2	3	3	6
improved hygiene/				
sanitation			7	7
improved				
connectivity			4	4
longer self sufficiency			4	4
increased				
staffing/funding	2	4	2	6
Nothing	4			4
less camp time			3	3
reduced exposure			3	3
improved logistic				
support	3			3
improved tech	3			3
fewer people		2		2
supplies		2		2
<u>Themes:</u>				
Logistics	16	29	17	44
Operations	5	12	26	37
Health and Safety			9	9
Management	2			2

What are the top new practices developed this summer (from large incidents or your own new practices) that you would advocate to abolish and why? Please list up to 3.

number responses 37

Descriptive codes: Count

Nothing	10
other	5
meal issues	4
unnecessary health	
protocols	3
virtual briefings	2
inter-module	
interaction limits	1
outdoor masks	1
payment system	
issues	1
time card issues	1

Themes:

Management	7
Logistics	4
Connectivity	2

Are there any changes to practices that you would have liked to implement but were unable to? If yes please briefly explain.

	Count	Percent
No	46	78
Yes	13	22
Total	59	100

number open ended responses 14

Descriptive codes: Count

other	5
covid testing	3
additional vehicle	2
improved self	
sufficiency	2
improved tech	2
logistics	2
waste reduction	1

Themes:

Health and Safety	3
Operations	3
logistics	4

Are there any changes to practices that you would have liked to see implemented but did not have the power to change? If yes please briefly explain.

	Count	Percent
No	37	370
Yes	24	240
Total	61	610

number open ended
responses

24

Count

Descriptive codes:

additional vehicle	2
improved facilities	1
improved support	2
improved tech	1
improved training	1
improved virtual processes	2
increased staffing	1
logistics	1
other	7
testing	5

Themes:

health & safety	5
Logistics	6

number people who responded to at least one of these questions

Is there anything that you tried at the beginning of this year that seemed like a good idea but ended up being problematic?

Descriptive codes:	Count
Nothing	14
health protocols	12
other	7
cooking/ meals	3
crew cohesion	3
logistics	2
virtual training	1

Themes:	
Health and Safety	13
Management	12
Logistics	3

We chose not to ask in detail about fireline operations as our initial outreach suggested that COVID-19 did not substantially change this aspect of fire management. However we are interested in feedback regarding those topics. Were there any changes to fireline operations that worked well or caused issues? If so please tell us a bit about them and what were they and what were the associated outcomes?

number responses 40

<u>Descriptive codes:</u>	Count
No	12
Fire line was the same	8
Problem: Health protocols	6
Problem: other	5
Worked Well: health protocols	5
Problem: logistics	3
Worked well: Closer to the line	2
Worked well: other	2
Problem: communication	1
Worked well: virtual processes	1

Themes:

Mangement (Health)	11
Logisitcs	3
Operational efficiency	3
Communication	1

Similarly we chose not to ask in detail about Type 3 -5 fires as many of the practices developed for this season focused on large fire operations. However we are interested in feedback regarding those topics. Were there any changes to Type 3-5 fire management that worked well or caused issues? If so please tell us a bit about them and what were they and what were the associated outcomes?

number responses 40

Descriptive codes: Count

covid	9
Logistics	8
management	6
No	6
other	5
communication	3

Worked well: other	3
interaction	2
Problem: other	2
operations	1
Worked Well:	
Mitigation	1

Worked well: spiking	1
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Themes:

Health and Safety	11
Logistics	8
Management	6
Communication	3
Operations	3