

Quantitative Risk Assessment (QRA) of COVID-19 Outbreak in Fire Camp

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Key Points

- Limited testing, testing errors, asymptomatic cases, and possible failures of screening suggest the inevitability of an infected individual arriving at a large fire incident
- If and when that occurs, COVID-19 could spread rapidly at a traditional large fire camp
- Given an outbreak, mortalities could be substantial under baseline and worst-case scenarios, especially if smoke exposure and other factors exacerbate COVID-19 risk
- Aggressive screening and testing (if it becomes available) to initially isolate infected individuals can reduce the total number of infections, but the benefits diminish as incident duration increases
- Aggressive social distancing measures (e.g., modular isolation, coyote camps, increased use of telecommunications) are likely to be more effective at reducing the total number of infections
- Best case scenario assumes screening/testing and social distancing are implemented jointly and effectively, but does not eliminate risk
- Intensive adherence to social distancing guidelines is essential, any intermingling of otherwise isolated modules introduces points of failure
- Results presented here are for individual incidents; effects will be compounded across multiple fires and may introduce systemic disruptions in capacity

Background

The wildland fire management community is already planning modifications to suppression strategies, operations, and logistics in order to mitigate the variety of risks posed by COVID-19. One of these risks is a COVID-19 outbreak in a traditional large fire camp. This analysis helps quantify that risk, to support risk-informed planning and decision making.

Firefighters know all too well the occurrence and unpleasantness of “[camp crud](#),” but the COVID-19 global pandemic is dramatically different. The virus is more infectious, lasts longer, and is more deadly than prior infectious disease threats. At present, we lack the capacity to implement widespread testing. [Recent findings suggest that screening may be less effective because 1 in 4 cases may be asymptomatic.](#) Together, these data suggest the inevitability of a firefighter arriving at a large fire camp and spreading COVID-19. Under business as usual on a large, long-duration incident, **the presence of any infected individuals could lead to widespread infection and mortality.**

Here we report preliminary findings from an [epidemiological simulation model of COVID-19](#) tailored to the context of a wildfire incident, where the population at the fire camp changes over time. We explore how rates of infection and mortality vary with incident mobilization/demobilization dynamics, duration, and the number of assigned personnel using real resource assignment data from three historical fires. Further, we adjust the model to explore the benefits of two risk mitigations measures that incident management teams may adopt: increasing screening/testing, and increasing social distancing measures.

Model Results

We simulate COVID-19 outbreaks on three 2017 fires chosen to represent different incident types: the Highline Fire, which burned for much of the summer but personnel peaked early in the effort, the Lolo Peak Fire, which spanned July through September and had a relatively symmetric mobilization and

demobilization phase, and the Tank Hollow Fire, which was shorter than the other two and had fewer personnel throughout the incident. Figure 1 shows the mobilization/demobilization dynamics for the three fires we selected, providing a sense of perspective on when in the season they occurred, how long they lasted, and how many personnel were on the fire.

We feed these incident dynamics into the COVID-19 model to analyze different scenarios. Table 1 shows the variety of scenarios we analyzed, which includes a range from best to worst case along with two individual risk mitigation options: increasing screening/testing (assuming testing may become available further into the season), and aggressive social distancing at camp (e.g., no catering, increased use of spike camps, remote briefings). The best case assumes both mitigations are implemented jointly and effectively. We also explore variable mortality rates, which may differ from what has been observed for the general population due to responders' increased smoke exposure and fatigue, among other factors.

Figure 2 shows the paths of infectious individuals and total infections under the baseline assumptions for each fire over time. Total infections are defined as individuals who became infected on the incident whether they remained on the incident or left. Maximum daily infections generally peak around the time of peak assigned personnel. Despite the Highline Fire having a greater number of assigned personnel at the peak, the Lolo Peak Fire had by far the greatest number of infected due to the longer duration with substantial personnel assigned and the total number of personnel that worked on the fire.

Figure 3 shows cumulative mortality under different rates over time for each fire. The results suggest that with medium to high mortality rates we could anticipate mortality levels that are substantially greater than historical causes like entrapments, heart attacks, and accidents.

We explore the impact of increased screening/testing by varying the percentage of arriving individuals that are infected. Figure 4 compares the total number of infections on each fire under low, medium, and high percentages of infected arrivals at camp corresponding to different levels of screening/testing. The results indicate that screening and testing procedures are important for shorter duration fires where many people are entering and leaving the camp. However, on long-duration fires like Lolo Peak, many of the infections occur on the fire making the testing less important than aggressive social distancing (see below).

We explore the impact of aggressive social distancing by varying the transmission rate derived from R_0 (the basic reproduction number, or the number of secondary cases resulting from a single case). Reducing contacts in the camp by dispersed camping or remote briefings will reduce transmission. Figure 5 compares the total number of infections on each fire under low, medium, and high transmission scenarios corresponding to different levels of social distancing. Social distancing is comparatively more effective than screening/testing, and can substantially reduce cases, especially on long duration fires like Lolo Peak.

Beyond the direct health impacts, infected persons are also unable to work, reducing the workforce available to contain the fire. The loss of personnel can be substantial: up to 10% of the workforce may be incapacitated (Figure 6) in the worst case scenario, though other scenarios show smaller effects (less than 5%). The most promising option appears to be implementing both aggressive screening/testing and social distancing measures on-site at the fire camp (Figure 7; best case). Certainly results are driven by the assumption that incoming infections and infection rates can be reduced, but nevertheless results do suggest aggressive mitigation can help sustain firefighting capacity over time.

Table 1: Scenarios and corresponding model parameters. The infection rate parameter is drawn from [Wu et al. \(2020\)](#); medium is the baseline observed rate of 2.38, low is half of the baseline (1.34), and high is twice the baseline (5.36). The percentage of individuals arriving at the fire infected is varied from low (0.1%) to medium (1%) to high (5%).

Scenario	Infection rate (R0 parameter)	Percent of arriving individuals that are infected
Best case	Low	Low
Worst case	High	High
Baseline	Medium	Medium
Increased testing	Medium	Low
Aggressive social distancing	Low	Medium

Total Personnel on 3 Incidents in 2017

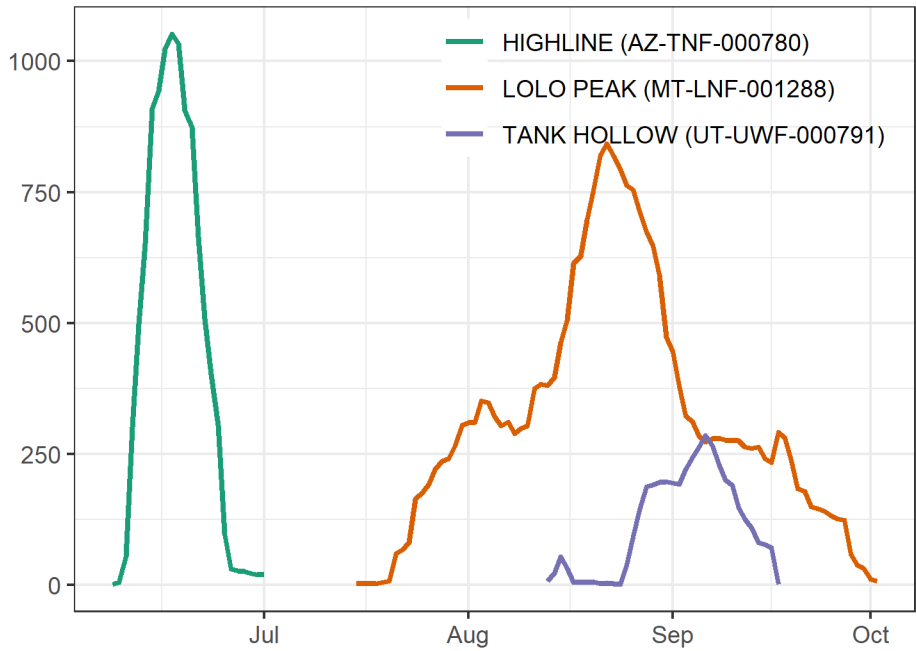


Figure 1: Total personnel assigned to large fire incidents over time; data from the Resource Ordering and Status System

Epidemic Curves (log scale)

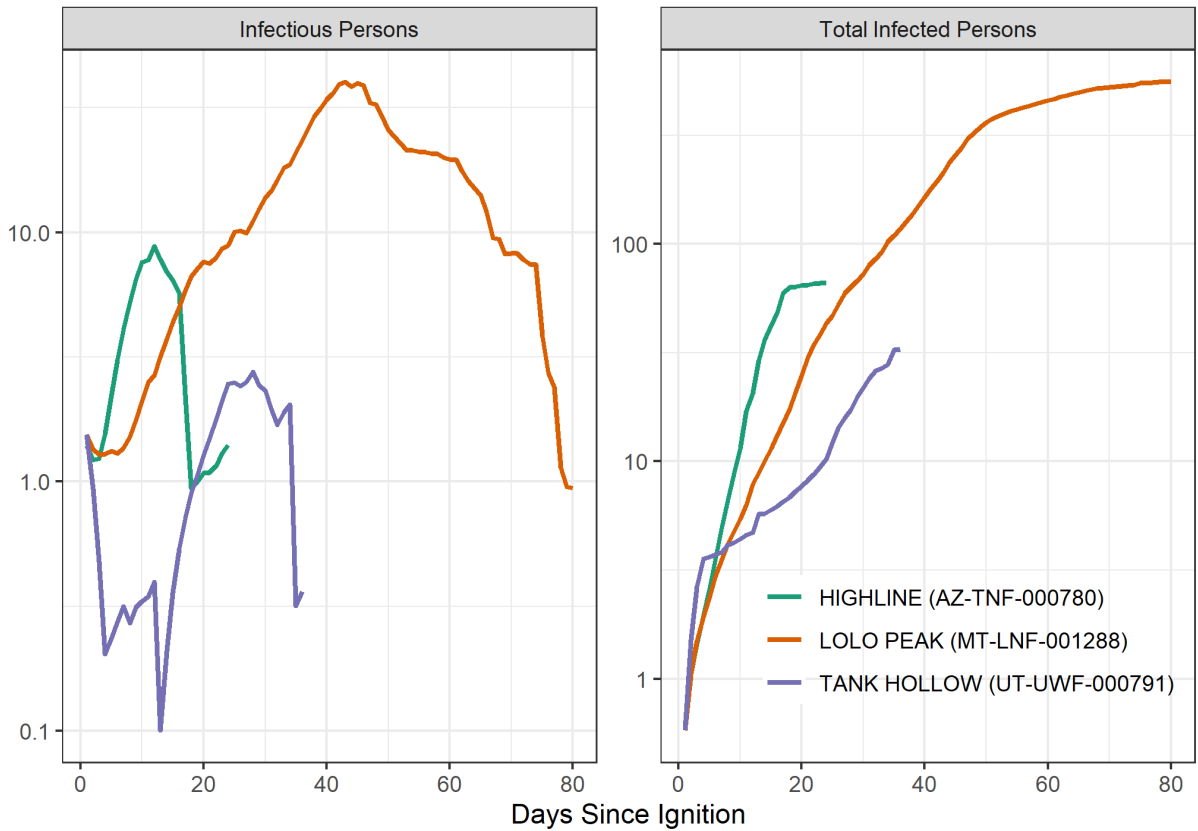


Figure 2: Infectious persons and total infected persons over the duration of each incident, under the baseline scenario. Note that the infectious status is temporary whereas the total number of infections is cumulative. Note that the vertical axis is log scaled.

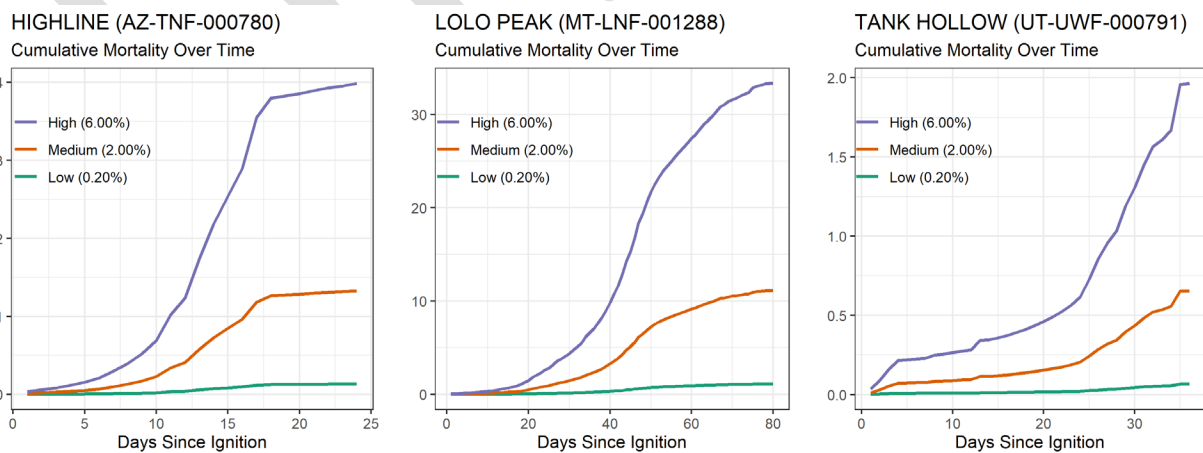


Figure 3: Cumulative mortality over time for the baseline scenario. Note that the vertical axis is not log scaled for this figure.

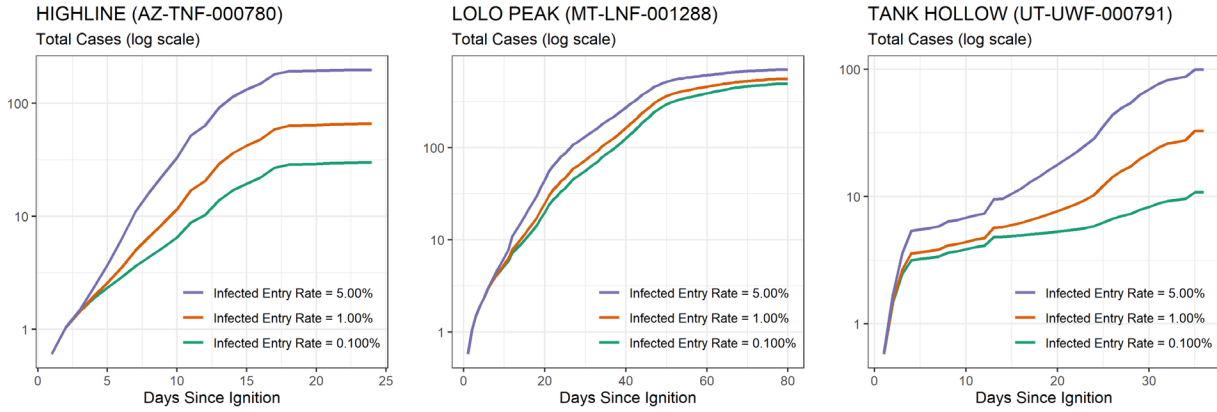


Figure 4: Total number of infected individuals over the duration of each incident under low (0.1%), medium (1%), and high (5%) entry rates of infected individuals. Note that the vertical axis is log scaled.

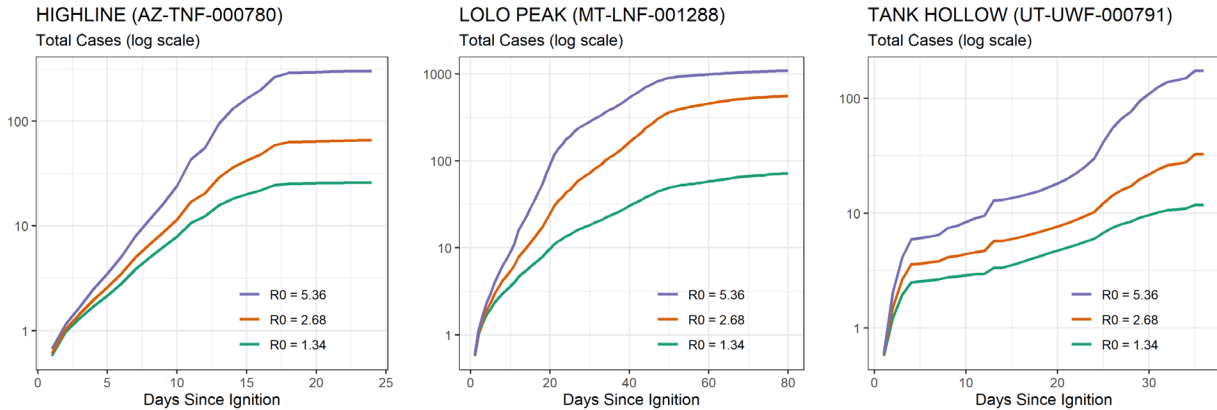


Figure 5: Total number infected individuals over the duration of each incident under low ($R_0=1.34$), medium ($R_0=2.68$), and high ($R_0=5.36$) infection rates. Note that the vertical axis is log scaled.

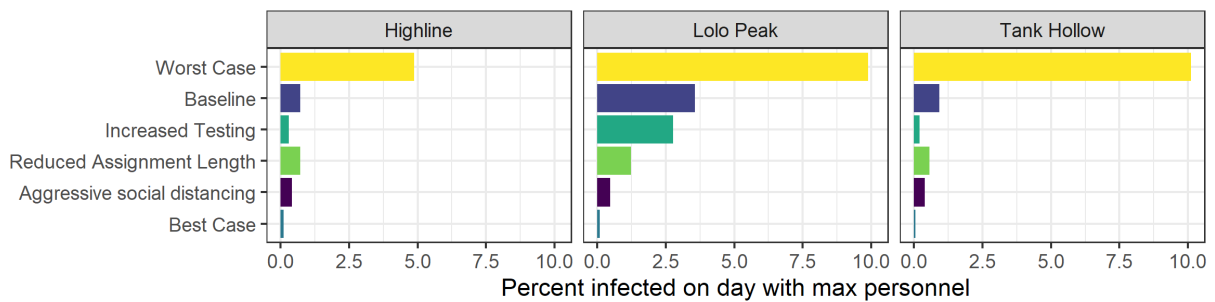


Figure 6: A comparison of the percentage of the workforce infected on the day with the largest number of personnel working across fires and scenarios.

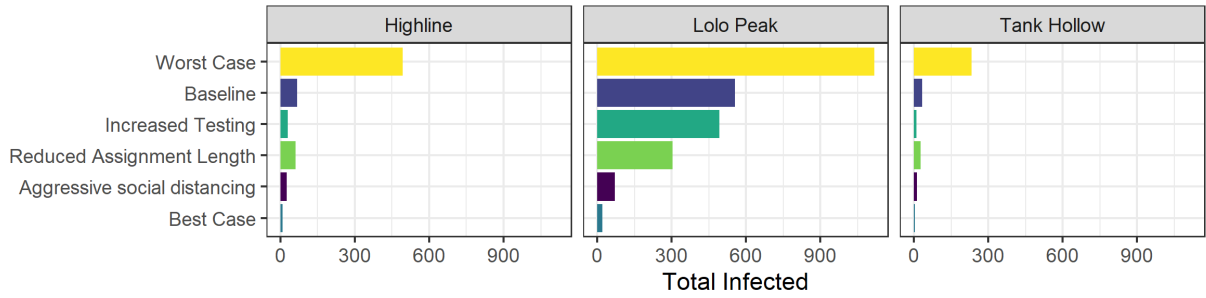


Figure 7: A comparison of the total infected persons across fires and scenarios. Total infected for the best case scenario is approximately 8, 21, and 4 individuals for the Highline, Lolo Peak, and Tank Hollow fires, respectively.

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