Review of Search and Rescue Response Guidelines to COVID-19.

Robert J. Koester PhD, FRGS

School of the Environment, Geography and Geosciences, University of Portsmouth

dbS Productions

UK, USA

Email: Robert@dbs-sar.com

Abstract

COVID-19 has impacted how search and rescue (SAR) teams respond to incidents, conduct operations, provide patient care, and demobilize. This review looks at COVID-19 symptoms, transmission, and risk factors that might affect search and rescue response. It then looks at risk assessment that might impact the development of COVID-19 operational guidelines along with several general guidelines that have been developed. A literature search was conducted and six response guidelines from search and rescue organization were located. They represented Maritime, Urban, Helicopter, and Ground Search and Rescue organizations. Elements of each guideline are assessed and important differences between different types of SAR functions explored. All SAR teams should develop guidelines on how to best to respond not only during the COVID-19 pandemic but for future infectious disease incidents as well.

Key Words: Response guidelines, protocols, COVID-19, Search and Rescue

Introduction

On December 31, 2019, twenty-seven cases of pneumonia of unknown etiology were reported to the World Health Organization (WHO) from Wuhan City, China. (H. Lu, 2020). The causative agent, a virus, was identified from throat swab samples and then named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The disease was named COVID-19 by the WHO. (2020f). On March 11, 2020 COVID-19 was declared a global Pandemic by WHO (Cucinotta, 2020). As of June 8, 2020 the total confirmed worldwide cases exceed 7 million cases and over 400,000 deaths. (Johns Hopkins University & Medicine, 2020). In the United States it has resulted in the deaths of 29 EMS workers (EMS1, 2020), 36 firefighter deaths (FireRescue1, 2020), and 54 law enforcement deaths (PoliceOne.com, 2020). COVID-19 has impacted how search and rescue (SAR) organizations respond to incidents, with several organizations developing response guidelines.

Although, COVID-19 represents a novel coronavirus disease with much unknown, several important papers have started to describe the outbreak. Rothan and Byrareddy (2020) reviewed the symptoms, epidemiology, transmission, pathogenesis, phylogenetic analysis and future directions. Rodriguez-Morales et al (2020) reviewed clinical, laboratory and image features, outcomes, risk factors, and prevalence of comorbidities. Across the 27 articles assessed, 20.3% of patients required intensive care unit (ICU) and of hospitalized patients, 13.9% had a fatal outcome. Yang et al (2020a) looked at seven studies and found the most common symptoms were fever (91.3%), cough (67.7%), fatigue (51.0%), and difficulty breathing (30.4%). The most common co-morbidities were hypertension (21.1%), diabetes (9.7%), cardiovascular disease (8.4%), and respiratory system disease (1.5%). Shereen, Khan, Kazmi, Bashir, and Siddique (2020) looked at the origin and characteristics of human coronaviruses.

Symptoms

The US Center for Disease Control (CDC) originally listed three symptoms of fever, cough, and shortness of breath (Jernigan, 2020). Currently, the CDC (2020i) lists the following symptoms; cough, shortness of breath or difficulty breathing, fever, chills, muscle pain, sore throat, new loss of taste or smell, nausea, vomiting, or diarrhea. Some additional symptoms listed in the literature include sputum production, headache, hemoptysis, lymphopenia, and Chilblain-like lesions on feet and hands, (Ren, et al., 2020; Huang, et al., 2020; Wang, Tang, & Wei, 2020; Carlos, Dela Cruz, Cao, Pasnick, & Jamil, 2020; Landa, Mendieta-Eckert, Fonda-Pascual, & Aguirre, 2020). The symptoms typically appear after an incubation period of 5.2 days (Li, et al., 2020) with a range of 2-14 days (CDC, 2020i). Lauer et al. (2020) similarly reported only 2.5% will show any symptoms after 2.2 days, the median incubation period to be 5.1 days (CI, 4.5 – 5.6 days), and 97.5% will show symptoms within 11.5 days (CI, 8.2 – 15.6 days). However, a unique aspect of COVID-19 is the number of asymptomatic carriers. One report from China had 130 of the 166 COVID-19 infections (78%) detected as being asymptomatic (Day, 2020). A study done onboard the Diamond Princess cruise ship found of the 634 confirmed cases 328 (50.8%) were asymptomatic (Mizumoto, Kagaya, Zarebski, & Chowell, 2020).

Transmission

Knowledge about the transmission of COVID-19 is still limited and being updated. Estimates of the R factor (Reproduction number), which represents the average number of people infected by a person, range from 1.4 to 6.89 with an average of 3.28 from twelve different studies (Liu, Gayle, Wilder-Smith, & Rocklov, 2020). However, this represents an average number. It is possible that many people might infect few people and others might be “superspreaders” that infect many people. This characteristic is accounted for by a value known as “k” (dispersion factor) which describes how much the disease clusters. The lower the k factor the more the disease spreads by fewer people. For the Middle East Respiratory Syndrome (MERS) outbreak k was 0.25, for the Severe Acute Respiratory

Syndrome (SARS) outbreak k was 0.16 and for COVID-19 k appears to be 0.1 (10% of cases cause 80% of the spread) according to Endo et al. (2020) or a median value of 0.54 according to Julien and Christian (2020) using mathematical simulations (Lloyd-Smith, Schreiber, Kopp, et al., 2005). This supports that superspreading plays a major role in the transmission of COVID-19. Many superspreading events have been documented in a COVID-19 database (Leclerc, Fuller, Knight, Funk, & Knight, 2020).

Infections from respiratory droplets of infected individuals are thought to be the predominant human-to-human transmission mode (Peeri, et al., 2020; Huang, et al., 2020). The CDC (2020d) reports that COVID-19 is mainly transmitted through close contact from person-to-person and more specifically: between people who are within 6 feet of each other; through respiratory droplets when an infected person coughs, sneezes, or talks; and when droplets with SARS-CoV-2 land in the mouths or noses of people who are nearby or possibly inhaled. It can also be spread by people who are not showing symptoms. The CDC goes on to report that "it may be possible that person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes." The amount of time the virus is capable of surviving (no virus detected) on plastic is 72 hours, 48 hours on stainless steel, 4 hours on copper, and 24 hours on cardboard. In aerosols the half-life was 1.1 to 1.2 hours (van Doremalen, et al., 2020). Bahl et al. (2020) reviewed 10 studies on horizontal droplet distance and found some evidence supporting aerosol transmission, with eight studies showing droplets travelled farther than 2 meters. In a review paper looking at use of outdoor recreational spaces Freeman and Eykelbosh (2020) acknowledge the potential for aerosol transmission but state the aerosoled virus is not a primary mode of transmission and does not appear at sufficient concentrations to cause an infection. Another study showed that virus samples recovered from air taken from a health care setting were not able to infect cultured cells (Santarpia, et al., 2020). This suggests that transmission is dependent on both close proximity to an infected person and being close for a certain period of time (Ontario Agency for Health Protection Promotion, 2020). The Department of Homeland Security (DHS) reported to the media a test conducted at the National Biodefense Analysis and Countermeasures Center in Maryland that the half-life of the virus on a stainless steel surface was 1.5 minutes at a temperature of 21-24C, humidity of 80%, and simulated sunlight (AFP-JIJI, 2020). In Japan, Nishiura et al (2020) reported that transmission was 18.7 times more likely indoors than outdoors based upon 110 cases. Qian et al. (2020) looked at 1245 confirmed cases of COVID-19 outbreaks where three or more people were involved and found only one outbreak occurred in the outdoors where a 27-year-old male had a conversation with another individual.

Risk Factors

COVID-19, like most diseases, does not treat everyone the same. The overall fatality rate in the US is 1.8%, for those under the age of 20 was zero, for age 65-74 was 2.7%, for age 75-84 was 4.3%, and for those over the age of 85 it was 10.4% (COVID, C., & Team, R, 2020). The CDC (2020g) lists the following risk factors for severe illness from COVID-19: age 65 or older, living in a nursing home or long-term care facility, and anyone with an underlying medical condition if not well-controlled. The medical conditions they list include: chronic lung disease or moderate to severe asthma, heart conditions, severe obesity (body mass index BMI of 40 or higher), diabetes, chronic kidney disease requiring dialysis, liver disease, and people who are immunocompromised. Several different conditions may result in being immunocompromised and the CDC lists: cancer treatment; smoking; bone marrow or organ transplantation; immune deficiencies; poorly controlled HIV or AIDS; and prolonged use of corticosteroids and other immune weakening medications. Williamson (2020) et al lists some additional hospital-based mortality risk factors after looking at 17 million adult patients in the United Kingdom. They used Hazard Risk (HR) as the measure with a score of one being baseline and a number greater than one representing increased risk of mortality. The study found the following Hazard Risk factors: age 80+ (12.6); age 70-80 (4.8); organ transplant (4.7); Diabetes (2.4); BMI >40 (2.3); age 60-<70 (2.1); Male compared to female (2.0); respiratory disease (1.8); recent cancer (1.6); liver disease (1.6); kidney disease (1.7); other immunosuppressive conditions (1.7); chronic heart disease (1.3); and Rheumatoid/Lupus/Psoriasis (1.2). Several other early review papers found similar results and report some additional risk factors such as smoking and hypertension (Vardavas & Nikitara, 2020; Zheng, et al., 2020; Yang J. , et al., 2020).

Objectives for Search and Rescue Response

Even with the COVID-19 pandemic and the resulting restrictions on outdoor activities, the need for first responders, specifically search and rescue services, remains. SAR organizations should have three major new concerns during pandemic response

1. Avoid transmitting or becoming infected by fellow response members and emergent volunteers.
2. Avoid transmitting or becoming infected by search subjects.
3. Avoid transmitting to family members and community.

All three of these objectives are interrelated. An infection transmitted from one team member to another could also result in transmission to family members or to a search subject. A superspreading event among a team could also significantly reduce the organization's ability to respond to incidents. Transmission from a search subject could eventually result in a secondary transmission to other response members and/or family members. It has been stated that search and rescue first responders, both members and organizations, have a higher moral obligation to prevent the transmission of COVID-19 (Boyer, 2020). An additional confounding factor in planning response

guidelines is the fact that many search and rescue responders are volunteers (Lois, 2003; Public Safety Canada, 2013; House of Commons, Transport Committee, 2005). Depending upon the team's organization, compensation for lost time or medical costs may not be available to members if they become infected.

Risk Assessment

In developing response guidelines that may limit operations it is always important to conduct a risk assessment. Well known operational risk assessments within search and rescue include the Green-Amber-Red (GAR) system developed by the USCG (2017). The GAR model has been modified by the National Park Service (NPS) and can be obtained as a downloadable mobile app (NPS, 2014). The Occupational Safety and Health Administration ([OSHA] 2020) prepared a publication called "Guidance on Preparing Workplaces for COVID-19" that starts with performing a risk assessment. It classifies workers at lower exposure risk, medium exposure risk, high, and very high exposure risk and then provides the appropriate guidance. SAR providers classified at very high exposure risk would be conducting aerosol-generating procedures such as intubation, cough induction, or invasive specimen collection on known or suspected COVID-19 patients. SAR providers classified at high exposure risk would be anyone who enters a room with a known or suspected COVID-19 patient, and those transporting a COVID-19 patient in enclosed vehicles, boats, or helicopters. Medium exposure for SAR providers would be those tasks that require frequent and/or close contact (within 2 meters) of those who may be infected with SARS-CoV-2. Here "may be a COVID-19 patient" does not mean known or suspected cases, but instead means a person who has frequent contact with travelers, areas with ongoing community transmission, and high contact with high-population-density work environments. Working in a SAR mobile command vehicle might be an example of medium exposure. Lower exposure is defined as "a job that does not require contact with people known to be, or suspected of being, infected nor with the general public". Clearly in SAR, different roles will face different risks for COVID-19. A remote field task with spacing greater than 2 meters will face less risk than mission base staff working in close quarters. A provider who needs to intubate a subject will face a larger risk. The World Health Organization has also produced a risk assessment tool aimed at health workers (WHO, 2020e). Another important concept in risk management is risk mitigation (USCG, 2017). For example, a team briefing with the entire team present in a small trailer can be mitigated with just the briefer and team leader under an awning outside while wearing a mask. Each task or component of the SAR response should be examined to determine how to lower risk.

General First Responder COVID Guidelines

Several organizations are responsible for providing guidance to first responders and other responders such as the CDC and WHO. They provide an excellent starting place for developing specific team or organization guidelines. The WHO has published several publications that are relevant. These include reports on COVID-19 roles and responsibilities of health workers, infection prevention and control during health care, rational use of personal protective equipment, and advice on the use of masks (2020b; 2020c; 2020d; 2020a).

The CDC has issued several pieces of advice that are relevant to SAR. The Interim Guidance for Emergency Medical Services (EMS Systems) applies to all first responders, including law enforcement, fire services, emergency medical services, and emergency management officials (CDC, 2020e). The guidance covers additional questions for 911 PSAPS, changes in patient assessment, recommended Personal Protective Equipment (PPE), precautions for Aerosol-Generating Procedures, transport of patients, documentation of patient care, cleaning of transport vehicles, follow-up and reporting measures, and EMS employer responsibilities. The guidance also provides an approved list of products that can be use against SARS-CoV-2 (EPA, 2020). The CDC (2020e) has also issued interim infection prevention and control recommendations for patients with suspected or confirmed coronavirus Disease 2019 in healthcare settings. The key points for SAR providers who may provide care to patients during a rescue include: limiting who is on scene, use of masks, use of PPE, patient placement, monitoring and managing healthcare providers, training and educating personnel, and other controls. Since respirators or N95 masks are specified in some circumstances as PPE and a shortage of masks may exist in some areas the CDC (2020a) has also provided guidance on decontamination and reuse of these facepiece respirators. In addition to a shortage of N95 respirators almost all PPE has faced supply shortages. Therefore, the CDC (2020h) issued guidance on strategies to optimize the supply of PPE and Equipment. The guidance addresses how eye protection, isolation gowns, gloves, facemasks, N95 respirators, powered air purifying respirators, elastomeric respirators, and ventilators should be used during conventional, contingency, and crisis capacity with the goal of extending PPE supplies. While the CDC has not issued any guidance specific to search and rescue it does have “FAQs for Wildland Firefighters,” who often set up remote operations similar to a search incident (CDC, 2020b). The CDC (2020c) also has established a web page for first responders that addresses cleaning and disinfection, preventive steps, exposure of critical workers, how to cope with stress, and managing fatigue.

The US federal government has prepared several other guidance documents that are relevant in developing and implementing COVID guidelines. The Technical Resources, Assistance Center, and Information Exchange (TRACIE) developed an EMS infectious disease playbook (ASPR TRACIE, 2017). While developed prior to COVID-19, this document provides guidance for many different infectious diseases that need to be taken into consideration and specifically addresses MERS which was caused by a similar coronavirus. It specifically provides guidance on dispatch actions; standard precautions; precautions for contact, droplets, and aerosols; special respiratory precautions;

precautions for Ebola virus disease/Viral hemorrhagic fevers (EVD/VHF) virus; and other special considerations. This guidance will be just as applicable once the COVID-19 crisis is over. The OSHA document (2020) previously described for risk assessment also provides helpful guidance on procedures for each risk level, workplace related impacts of COVID-19, how to develop an infectious disease response plan/guidelines, and workplace controls.

The American Heart Association (AHA) has issued interim guidelines for Basic and Advance Life Support in response to COVID-19. The AHA provided updated guidelines since previous guidelines did not address the impact of COVID-19. Cardiopulmonary resuscitation (CPR) creates extreme risk to providers since it requires aerosol-generating procedures such as chest compressions, ventilation, and intubation (Edelson, et al., 2020). van Doremalen et al. (2020) has demonstrated these procedures' viral particles remain suspended in the air with a one-hour half-life. The revised guidelines are essentially the same for pediatric and neonatal subjects due to the low risk of COVID-19. For adults the interim guidelines call for PPE, limiting personnel, adding a filter and a tight seal to bag-mask device, cuffed intubation or supraglottic airway and connection to ventilator with filter if possible. In the case of lay rescuer's hands-only CPR is recommended (Edelson, et al., 2020). CPR in the wilderness setting often calls for special guidelines. The Wilderness Medical Society has issued clinical practice guidelines that address CPR in the context of accidental hypothermia, drowning, and avalanche burial (Dow, et al., 2019; Schmidt, et al., 2019; Van Tiburg, et al., 2017). The International Maritime Rescue Federation (IMRF), International Lifesaving Federation's Medical commission (ILS-MC) and the International Drowning Researchers' Alliance (IDRA) have formed a joint working group to develop guidelines on drowning resuscitation in regards to COVID-19 (IMRF, 2020).

It is also important to review state and local guidance in developing response guidelines. These may have a direct impact on what each team may be allowed or restricted from in its response.

Methods

Search strategy

The goal was to locate examples of search and rescue response guidelines that reflect the impact of COVID-19. An initial literature search of Google Scholar, PubMed, OVID, Web of Science, and Google was conducted using the search terms of "Search and Rescue" plus COVID. A filter for only papers written in 2020 was applied. A query was also sent to the US Federal primary agencies for search and rescue as defined by the Emergency Support Function #9 (FEMA, 2016). Examples of international response guidelines would be accepted. A query was also sent to data contributors of the International Search and Rescue Incident Database (ISRID) (Koester, 2008). Papers or documents were selected if they addressed search and rescue response guidelines addressing COVID-19 issues. Papers/guidelines were then compared to determine which topics they addressed and provide examples to other SAR organizations.

Results

The literature search of Google Scholar returned 81 results; PubMed, OVID, and Web of Science zero results; and Google 8,720,000 results. The directed queries produced 4 results. A total of 6 papers/guidelines were found that met the criteria. Two articles were found from the Google Scholar search. Bredmose et al. (2020) describes the process of creating the actual guidelines for aeromedical transport of patients with COVID-19. Young (2020) describes the guidelines developed for a ground or land search and rescue in the Bay Area of California. Found through a general internet search was the "International Maritime Rescue Federation COVID-19: Guidance for SAR Organisations" which addresses maritime and coastal search and rescue (IMRF, 2020). Guidelines for Urban Search and Rescue (USAR) were found on the United Nations INSARG web page (INSARAG, 2020). The United Kingdom Maritime and Coastguard Agency created guidelines with representation from Mountain rescue, land search and rescue, cave rescue, and surf lifesaving organizations (Maritime and Coastguard Agency, 2020). The IMRF and INSARAG guidelines were also provided by the USCG as a result of the query. The Virginia Department of Emergency Management (VDEM) also provided an unpublished copy of its COVID-19 response guidelines developed by ground or land search and rescue teams (COVSAR, 2020).

	IMRF	INSARAG	Bredmose *et al.*	UKSAR	COVSAR	Young
Audience	Maritime	USAR	HEMS	Ground	Ground	Ground
Version Date	April 28	March 18	March 31	May 12	Apr 16	May 22
Dispatch Considerations						
Collect prior COVID intelligence about subject		✓	✓	✓		
Risk assessment	✓	✓	✓	✓		✓
Need to quarantine after deployment		✓				
Individual when not to respond to incident	✓		✓		✓	✓
Self-evaluation (fever + symptoms)	✓				✓	✓
Self-evaluation (previous travel + exposures)	✓				✓	✓
Self-evaluation (personal risk factors)	✓				✓	
Individual Welfare						
Medical check-in (fever + symptoms)		✓				✓
Standard precautions	✓	✓		✓	✓	✓
Different levels for PPE based on risk	✓		✓	✓		
Procedures if PPE limited			✓	✓	✓	
N95 fit tested masks discussed	✓	✓		✓	✓	
Required mask all times						✓
Open air distancing		✓		✓	✓	✓
Use of waterproof clothing as PPE				✓		
PPE vs safety equipment		✓	✓	✓		
Training for donning and doffing PPE	✓		✓			
Training with simulated COVID patient			✓			
Hydration				✓		
If SAR member becomes sick	✓	✓	✓			✓
Response						
Travel in Convoy: Single or smaller number		✓				✓
Compartment Isolation	✓		✓			
Canines: limited contact		✓			✓	
Canines: kenneled during rest and sleep		✓			✓	
Briefings (limiting number)					✓	✓
Briefings (social distancing)					✓	✓
Interviews (tele-conference or distance)						✓
Ground search team tasks (social distance)					✓	✓
Use of Emergent Volunteers					✓	
Procedures for maps, forms, radios				✓	✓	✓

Table 1. Comparison of different guidelines, continued on next page.

	IMRF	INSARAG	Bredmose *et al.*	UKSAR	COVSAR	Young
Facility Management/Base Camp/ICP						
Reduce/eliminate visitors	✓	✓	✓		✓	
Limiting building access to hygiene station	✓	✓	✓			✓
Segregating areas for crews	✓	✓	✓			
Enhanced cleaning of facility	✓	✓	✓			
Limiting training	✓		✓		✓	✓
Avoid sharing food/eating own food		✓	✓		✓	
No eating in sleeping quarters		✓	✓			
Isolation area if member becomes ill	✓	✓				
Subject Medical Care						
Don PPE for all subjects			✓	✓	✓	
Screening patients once contacted	✓				✓	
Wait for EMS alternate transport if possible	✓		✓	✓		✓
Place mask on subject	✓		✓	✓	✓	
Limiting providers giving care	✓		✓	✓	✓	✓
Limiting contact time with subject	✓			✓		
Higher level of PPE if suspected COVID (N95, eye protection, nitrile gloves)	✓	✓	✓	✓	✓	
Stay upwind of subject if possible				✓		
Proper doffing of PPE	✓	✓	✓	✓	✓	
Avoid enclosed or confined space				✓		
Portable isolation units			✓			
Patient packaging	✓		✓			
Resuscitation (CPR)						
Higher level of PPE	✓		✓	✓		
Avoid some respiratory procedures	✓			✓		
Modified BLS and ACLS CPR procedures	✓			✓		
Intubation procedures			✓			
Demobilization						
Reporting of ill responders		✓			✓	
Stress debriefing		✓			✓	
Change out of clothing				✓	✓	✓
Decontamination protocols for clothing	✓		✓	✓	✓	✓
Decontamination protocols for equipment	✓		✓	✓	✓	✓
Disposable of PPE	✓		✓		✓	✓

Guideline	SAR Type	AOR	Version	Location
IMRF	Maritime	Worldwide	April 28	download PDF
INSARAG	USAR	Worldwide	March 18	download PDF
Bredmose et al.	HEMS	Europe	March 31	download PDF
UKSAR	Ground	United Kingdom	May 12	download PDF
COVSAR	Ground	Virginia	May 16	See Appendix 1
Young	Ground	California	May 22	www.jounalofsar.com/issues

Table 2 Reviewed Guidelines source and characteristics. AOR=Area of Responsibility. HEMS=Helicopter EMS

Discussion

Every SAR organization should examine the impact of COVID-19 on their operations and how they will respond through formal guidelines. The six different guidelines reviewed all made some important observations in their introductions. First the guidelines were developed specifically to respond to changes in procedures, protocols, or existing guidelines due to COVID-19. Therefore, some aspects of dispatch considerations, individual welfare, response, facility management, medical care, and demobilization may be addressed in other documents. Since many of the details regarding COVID-19 remain unknown, dozens of new papers come out each day and since guidance from public health is evolving rapidly, the guidelines are subject to change. In fact, the UKSAR guidelines reviewed were the second version dated May 12, 2020 while the first version was dated April 17, 2020. Organizations needed to take into consideration federal and local guidance when developing guidelines. They also had to consider the nature of their particular responders. Some teams are paid responders who operate out of a manned facility while other teams are all volunteers who are responsible for providing all of their own equipment, gear, and even PPE. Finally, each organization had a different area of responsibility (AOR) and different missions which have a tremendous impact. While a ground team may distance themselves two meters apart rather easily, the image of a helicopter crew of pilot, co-pilot, flight nurse, flight paramedic, and patient trying to all stay 2 meters apart inflight creates a humorous but unachievable image. International USAR teams needed to address the impact of 14 days of quarantine upon returning to their host country after an incident. Therefore, when viewing table 1, which lists elements that each guideline addressed or did not address, the reader should not view the individual guideline as being deficient if an element is missing.

The major goal of this review article was to: 1) provide a fact-based foundation for creating COVID-19 response guidelines; and 2) share teams' guidelines, so that everyone can learn from each other and improve their own response capability. Depending upon the circumstances of the SAR organization and the community it serves the greatest threat of transmitting SAR-CoV-2 might be from fellow team members or from caring for patients. The reviewed guidelines demonstrated measures that addressed this issue. Some guidelines called for SAR members to assess themselves for symptoms and/or risk factors prior to response. Some guidelines called for an assessment of fever and symptoms upon arrival at the incident command post. Clearly symptomatic SAR responders should

be screened for COVID and kept from on-scene participation. Unfortunately, a large percentage of cases are asymptomatic or can transmit the disease prior to becoming symptomatic (Mizumoto, Kagaya, Zarebski, & Chowell, 2020; Tindale, et al., 2020). This would suggest that screening for symptoms alone would not suffice to mitigate spread among a SAR team.

Almost all of the reviewed guidelines called for some type of risk assessment. Some types of missions or procedures may not be worth the risk. Someone in command may need to make a go-no go decision. However, most risk management systems call for attempts to mitigate risk factors. This was commonly addressed in the guidelines by different levels of PPE being worn depending upon different risks of transmission of COVID-19. Some of the guidelines provided graphics or tables. The risk to a hasty team searching a wilderness trail on a sunny day is different than a medical provider considering advanced airway management on a known COVID-19 patient.

In developing guidelines, the reviewed example guidelines are an excellent starting place. However, teams will benefit from becoming familiar with the general first responder guidelines developed by the WHO, CDC, OSHA, ASPR TRACIE, and the AHA. Many of the reviewed guidelines give specific links to pages provided by these organizations. This allows the guidelines to be more concise but still makes it easy for readers to seek more in-depth information. It is critical to look at the primary sources frequently to determine if any information has been updated. While the EMS Infectious Disease Playbook was written prior to COVID-19 it does address the SARS-CoV-1 virus which was the cause of SARS (ASPR TRACIE, 2017). It also provides excellent instruction on the proper donning and doffing of PPE. Additional instructions for donning and doffing are given by the European Centre for Disease Prevention and Control and the CDC (ECDC, 2014) (CDC, 2020j). While the current focus is on COVID-19 search and rescue should eventually become familiar with the wide range of infectious diseases. Though many first responders (Fire and EMS) have received training in use of PPE it may be a new topic for many SAR providers. In addition, to the general references listed it is important that teams incorporate local guidelines into team response guidelines as well.

All of the reviewed guidelines addressed individual welfare. A self-evaluation prior to incident response (or reporting to duty) and then a formal medical check-in at the incident seems prudent. Since most of the guidelines performed some type of risk assessment for different tasks, roles, or contact with subjects, this was reflected in different levels of PPE suggested. Half of the reviewed guidelines gave suggestions if suggested PPE was not available. Some of the guidelines mentioned how suggested precautions from primary sources such as disposable gowns would not be practical in a search and rescue environment. One guideline suggested waterproof clothing as an alternative. Other guidelines mention how fire-retardant flight suits, life preservers, and other safety equipment might not be suitable with some of the PPE recommendations.

The area of greatest diversity was on recommendations for masks. Most guidelines recommended putting a mask on subjects, although the INSARAG guidelines (2020) point out, it should be a surgical mask and not a N95 mask, which needs to be fitted and can increase respiratory distress. A majority of the reviewed guidelines addressed N95 respirators, which often remain in limited supply. Paxton et

al. (2020) provides a detailed review of the literature on N95 masks and methods to reuse them. Most of the reviewed guidelines conducted a risk assessment and recommended masks for responders only under specified conditions. The wearing of masks under low risk conditions may have some negative results for response. In the aeromedical context and maritime environments, masks can interfere with communications with the crew, (Bredmose, et al., 2020; IMRF, 2020). This has been backed up by more formal studies on masks' impact on communications, causing headaches, discomfort, and a delay in performing intubation (Burton, et al., 2020). A study on the impact of wearing a respirator-type mask while performing light, moderate, or heavy work found several effects, including an increase in respiratory rate, heart rate, and both systolic and diastolic blood pressure when compared to non-respiratory wear (Jones, 1991). The higher the work load, the greater the impact. (Jones, 1991). Under normal circumstances a surgical mask should be changed after becoming wet or every 4 hours (Lepelletier, et al., 2020). Therefore, some SAR environments may reduce the effectiveness of surgical mask.

All of the reviewed guidelines provided suggestions on how response activities could be modified to reduce exposure risk. These were practical suggestions from single responder in a personally owned vehicle to keeping pilots separate from medical crew. Some of the guidelines addressed the use of canines during the response phase.

SAR responders face a wide assortment of facilities, bases, and incident command posts depending upon several factors. Aeromedical response typically has a fixed hanger facility manned by regular crews. Some ground teams have no fixed facility but simply responders responding to an incident command post. Maritime response is usually directed from a rescue coordination center but the responding resources typically don't have a central base. Therefore, the recommendation for reducing transmission of COVID-19 was different for each SAR provider.

All of the reviewed guidelines addressed how subject medical care would be performed. For some SAR organizations conducting searches it is possible to conduct some amount of investigation while searching or responding to a subject. Therefore, it might be possible to have some understanding of the risk factor of the subject having COVID-19. In some rescue situations this knowledge may be unknown. Several of the guidelines applied a risk assessment to determine if they were the best resource to even provide medical care, other resources may have limited alternatives. While, the AHA has provided revised guidelines for BLS and ACLS resuscitation (CPR), not all of the reviewed guidelines addressed this issue (Edelson, et al., 2020). It might even be required to further modify these recommendations for the wilderness environment.

Demobilization of an incident was addressed by all of the reviewed guidelines, from decontamination protocols to stress debriefing. Two of the guidelines specifically addressed reporting of any ill responders. This is a step that should be addressed in all guidelines, although perhaps it was addressed in other organizational protocol.

Limitations

While this review looked at six different guidelines from four different sectors of search and rescue this doesn't represent the entire spectrum of search and rescue. The various disciplines of SAR include; rope rescue, water (flat, swiftwater and maritime), ice, wilderness (sometimes called ground or land), structural collapse, trench collapse, cave rescue, dive rescue, motor vehicle rescue, technical animal rescue, air rescue and mine rescue (JSAR, 2020). Clearly, not all disciplines of SAR were represented by this review. In addition, some search and rescue teams often do not wish to have guidelines or protocols shared widely because of fear of litigation. Another limitation of this paper was it only looked specifically at COVID-19 guidelines. Many teams may have addressed issues of decontamination, stress relief, PPE, and similar issues in other existing guidelines. Finally information is changing rapidly, so many papers cited were placed on non-peer review severs, and the final papers may change as they go through peer-review.

Conclusion

The goal of this review paper was to help other SAR responder's develop guidelines that address COVID-19 issues. First by providing a fact-based understanding of symptoms, transmission, and risk factors associated with COVID-19. Next, by applying a risk assessment of different roles and the COVID-19 potential of subjects it should be possible to mitigate the risk to rescuers. The best place to start the development of SAR-specific guidelines is from several high quality general COVID-19 guidelines generated by subject matter experts based upon research. Finally, these guidelines must be modified to address the unique factors and working conditions faced by search and rescue providers. Yet, the range of search and rescue is broad, so they must meet the unique needs of each team and environment. It is hoped that the six reviewed guidelines provided will give other SAR teams insight in creating their own guidelines. It goes without saying that knowledge of COVID-19 is changing with new studies and information coming out daily. In, fact many of the papers cited in this review have not finished undergoing peer review and even published papers get retracted. Therefore, authors of guidelines must stay current on new developments.

Acknowledgement

Special thanks to Brian Saunders of the Virginia Department of Emergency Management (VDEM) who provided the COVSAR guidelines, Richard Button of the USCG who provided copies of several guidelines, Theresa Crossley of the International Maritime Rescue Federation for sharing the IMRF guidelines, and Chris Young for sharing guidelines from the San Francisco Bay Area.

About the Author

Robert J. Koester first joined the Appalachian Search & Rescue Conference in 1981 and since then has participated in hundreds of searches, including over a hundred as Incident Commander. He holds a Ph.D. from the University of Portsmouth in search theory and a MS and BA from the University of Virginia in biology (neurobiology). His contributions to search and rescue include seminal research on search theory and lost person behavior along with creating the International Search and Rescue Incident Database (ISRID). He is an instructor for the Virginia Department of Emergency Management since 1988 and past president (15 years) of the Virginia Search and Rescue Council. He is currently developing SAR software called FIND, for the US DHS S&T Directorate. He also developed courses for DCJS and was a Cardiac Technician for twelve years with CARS. He is the CEO of dbS Productions which provides research, software & publications, and training services. He is also a visiting researcher at the University of Portsmouth. Robert has authored dozens of books and research articles on search and rescue, including *Lost Person Behavior*, and is widely cited. He has traveled internationally to present.

Abbreviations

ACLS	Advanced Cardiac Life Support
AHA	American Heart Association
AIDS	Acquired immunodeficiency syndrome
AOR	Area of Responsibility
ASPR	Assistant Secretary for Preparedness and Response
BLS	Basic Life Support
BMI	Body Mass Index
CDC	Center for Disease Control
COVSAR	Commonwealth of Virginia Search and Rescue
CPR	Cardio-Pulmonary Resuscitation
DHS	Department of Homeland Security
EMS	Emergency Medical Service
EPA	Environmental Protection Agency
EVD	Ebola virus disease
GAR	Green-Amber-Red
HEMS	Helicopter Emergency Medical Services
HIV	Human immunodeficiency virus
HR	Hazard Risk
ICP	Incident Command Post
ICU	Intensive Care Unit
IDRA	International Drowning Researchers Alliance
ILS-MC	International Lifesaving Federation - Medical Committee

IMRF	International Maritime Rescue Federation
INSARAG	International Search and Rescue Advisory Group
ISRID	International Search and Rescue Incident Database
k	dispersion factor
MERS	Middle East Respiratory Syndrome
NPS	National Park Service
OSHA	Occupational Safety and Health Administration
PPE	Personal Protection Equipment
R	Reproduction number
SAR	Search and Rescue
SARS	Severe Acute Respiratory Syndrome
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
TRACIE	Technical Resources, Assistance Center, and Information Exchange
UKSAR	United Kingdom Search & Rescue
USAR	Urban Search and Rescue
USCG	United States Coast Guard
VDEM	Virginia Department of Emergency Management
VHF	Viral hemorrhagic fevers
WHO	World Health Organization

References

AFP-JIJI. (2020, April 29). *U.S. government reveals details of coronavirus sunlight study.* Retrieved from the japan times: https://www.japantimes.co.jp/news/2020/04/29/world/science-health-world/us-coronavirus-sunlight-study/#.Xs1ohP9KhhE

ASPR TRACIE. (2017, June). *EMS Infectious Disease Playbook.* Retrieved from EMS.GOV: https://www.ems.gov/pdf/ASPR-EMS-Infectious-Disease-Playbook-June-2017.pdf

Bahl, P., Doolan, C., de Silva, C., Chughtai, A. A., Bourouiba, L., & MacIntyre, C. R. (2020). Airborne or Droplet Precautions for Health Workers Treating Coronavirus Disease 2019? *The J. of Infectious Diseases*. Retrieved from https://doi.org/10.1093/infdis/jiaa189

Boyer, C. (2020). *COVID-19 Thoughts*. Retrieved from NASAR: http://www.nasar.org/2020/03/19/covid-19-thoughts/

Bredmose, P. P., Diczbalis, M., Butterfield, E., Habig, K., Pearce, A., Osbakk, S., . . . O'Neill, J. (2020). Decision support tool and suggestions for the development of guidelines for the helicopter transport of patients with COVID-19. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 28*. Retrieved from https://doi.org/10.1186/s13049-020-00736-7

Burton, C., Coles, B., Smith, S., Toomey, E., Chan, X., Ross, L., & Greenhalgh, T. (2020). Performance and impact of disposable and reusable respirators for healthcare workers during pandemic respiratory disease: A rapid evidence review. *medRxiv*. Retrieved from https://doi.org/10.1101/2020.05.21.20108233

Carlos, W. G., Dela Cruz, C. S., Cao, B., Pasnick, S., & Jamil, S. (2020). Novel Wuhan (2019-nCoV) coronavirus. *Am. J. Respir. Crit. Care Med., 4*, 7-8. doi:10.1164/rccm.2014P7

CDC. (2020a, April 29). *Decontamination and Resuse of Filtering Facepiece Respirators.* Retrieved from Centers for Disease Control and prevention: https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/decontamination-reuse-respirators.html

CDC. (2020b, May 11). *FAQs for Wildland Firefighters.* Retrieved from Center for Disease Control and Preventation: https://www.cdc.gov/coronavirus/2019-ncov/community/wildland-firefighters-faq.html

CDC. (2020c, May 7). *First responders, Law Enforcement, and Public Services*. Retrieved from Center for Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/community/first-responders.html

CDC. (2020d). *How COVID-19 Spreads*. Retrieved from Centers for Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html

CDC. (2020e, March 10). *Interim Guidance for Emergency medical Services (EMS) Systems and 911 Public Safety Answering Points (PSAPS) for COVID-19 in the United States.* Retrieved from Centers for Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-for-ems.html

CDC. (2020f, May 18). *Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings.* Retrieved from Centers for Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Finfection-control%2Fcontrol-recommendations.html

CDC. (2020g). *People Who Are at higher Risk for Severe Illness*. Retrieved from Centers fo Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-at-higher-risk.html

CDC. (2020h, May 18). *Strategies to Optimize the Supply of PPE and Equipment.* Retrieved from Centers for Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/index.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhcp%2Fhealthcare-supply-ppe-index.html

CDC. (2020i, May 13). *Symptoms of Coronavirus*. Retrieved from Centers for Disease Control and Prevention: https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html

CDC. (2020j, May 11). *Use Personal Protective Equipment (PPE) When Caring for Patients with Confirmed or Suspected COVID-19.* Retrieved from Center for Disease Control and Preventation: https://www.cdc.gov/coronavirus/2019-ncov/downloads/A_FS_HCP_COVID19_PPE.pdf

COVID, C., & Team, R. (2020). Severe outcomes among patients with coronavirus disease 2019 (COVID019) - United States. *MMWR Mob Mortal Wkly Rep, 69*(12), 343-346. Retrieved from http://www.ecie.com.ar/images/paginas/COVID-19/4MMWR-Severe_Outcomes_Among_Patients_with_Coronavirus_Disease_2019_COVID-19-United_States_February_12-March_16_2020.pdf

COVSAR. (2020). *COVSAR COVID-19 Protocols.* Staunton: Commonwealth of Virginia Search and Rescue.

Cucinotta, D. &. (2020). WHO Declares COVID-19 a Pandemic. *Acta biomedica: Atenei Parmensis, 91*(1), 157-160. doi:10.23750/abm.v91i1.9397

Day, M. (2020). Covid-19: four fifths of cases are asymptomatic, China figures indicate. *BMJ*. Retrieved from https://doi.org/10.1136/bmj.m1375

Dow, J., Giesbrecht, G. G., Danzl, D. F., Brugger, H., Sagalyn, E. B., Walpoth, B., & et al. (2019). Wilderness Medical Society Clinical Practice Guidelines for the Out-of-Hospital Evaluation and Treatment of Accidental Hypothermia: 2019 Update. *Wilderness & Environmental Medicine*, S47-S69. Retrieved from https://doi.org/10.1016/j.wem.2019.10.002

ECDC. (2014, December 2). *ECDC Tutorial Critical aspects of the safe use of PPE*. Retrieved from thinglink: https://www.thinglink.com/scene/584726288351100929

Edelson, D. P., Sasson, C., Chan, P. S., Atkins, D. L., Aziz, K., Becker, L. B., . . . et al. (2020). Interim Guidance for Basic and Advanced Life Support in Adults, Children, and neonates with Suspected or Confirmed COVID-19. *Circulation*. Retrieved from https://doi.org/10.1161/CIRCULATIONAHA.120.047463

EMS1. (2020, May 4). *COVID-19: EMS deaths*. Retrieved May 22, 2020, from EMS1.com: https://www.ems1.com/coronavirus-covid-19/articles/covid-19-ems-deaths-jk5zWFziwYVYUaM4/

Endo, A., Abbott, S., Kucharski, A. J., & Funk, S. (2020). Estimating the over dispersion in COVID-19 transmission using outbreak sizes outside China [version 1; peer review 1 approved, 1 approved with reservations]. *Wellcome Open Res, 5*. Retrieved from https://doi.org/10.12688/wellcomeopenres.15842.1

EPA. (2020, May 28). *List N: Disinfectants for Use Against SARS-CoV-2.* Retrieved from EPA: https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2

FEMA. (2016). *Emergency Support Function #9 - Search and Rescue Annex.* Retrieved from FEMA: https://www.fema.gov/media-library-data/1470149567157-f1dc17ef606b8b82629bacf1c358dd55/ESF_9_Search_and_Rescue_Annex_20160705_508.pdf

FireRescue1. (2020, May 5). *COVID-19: Firefighter deaths: Tracking the coronavirus-related deaths of US firefighters*. Retrieved May 22, 2020, from FireRescue1: https://www.firerescue1.com/coronavirus-covid-19/articles/covid-19-firefighter-deaths-la0l8Hf2UzjRdTPC/

Freeman, S., & Eykelbosh, A. (2020). *COVID and outdoor safety: Consideratins for ouse of outdoor recreational spaces*. Retrieved from National Collaborating Centre for Environmental Health: https://ncceh.ca/documents/guide/covid-19-and-outdoor-safety-considerations-use-outdoor-recreational-spaces

H. Lu, C. S. (2020). Outbreak of pneumonia of unknown etiology in Wuhan China: they mystery and the miracle. *J. Med. Virol*, 25678.

House of Commons, Transport Committee. (2005). *Search and Rescue.* London: House of Commons. Retrieved from https://publications.parliament.uk/pa/cm200405/cmselect/cmtran/322/322i.pdf

Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., & et al. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet, 395*, 497-506. doi:10.1016/S0140-6736(20)30183-5

IMRF. (2020, March 23). *COVID-19: ILS-IMRF-IDRA Working Group on Drowning Resuscitation*. Retrieved from International Maritime Rescue Organization: https://www.international-maritime-rescue.org/news/covid-19-ils-imrf-idra-working-group-on-drowning-resuscitation

IMRF. (2020, April 28). *IMRF COVID-19 Operational Guidelnes.* Retrieved from IMRF: https://www.international-maritime-rescue.org/Handlers/Download.ashx?IDMF=77b41c9f-1553-4e69-b6bb-f2dcb1b1c729

INSARAG. (2020, March 18). *Guidance on USAR Operations in the COVID-19 Environment.* Retrieved from INSARAG: https://www.insarag.org/images/COVID-19_USAR_Operational_Guidance_for_INSARAG_FINAL_002.pdf

Jernigan, D. B. (2020, February 28). Update: Public Health Response to the Coronavirus Disease 2019 Outbreak - United States, February 24, 2020. *Morbidity and Mortality Weekly Report, 69*(8), 216-219. doi:10.15585/mmwr.mm6908e1

Johns Hopkins University & Medicine. (2020, May 22). *Coronavirus Resource Center*. Retrieved May 22, 2020, from Coronavirus Resource Center: https://coronavirus.jhu.edu/map.html

Jones, J. G. (1991). The Physiolgical cost of wearing a disposable respirator. *American Industrial Hygiene Association Jounral, 52*(6), 219-225. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/15298669191364631

JSAR. (2020). *Welcome to JSAR*. Retrieved from Journal of Search and Rescue: http://journalofsar.com/

Julien, R., & Christian, A. L. (2020). Pattern of early human-to-human transmission of Wuhan 2019 novel coronvirus (2019-nCov) December 2019 to January 2020. *Euro Surveill., 25*(4). Retrieved from https://doi.org/10.2807/1560-7917.ES.2020.25.4.2000058

Koester, R. J. (2008). *Lost Person Behavior: A Search and Rescue Guide on Where to Look - for land, Air and Water.* Charlottesville: dbS Productions.

Landa, N., Mendieta-Eckert, M., Fonda-Pascual, P., & Aguirre, T. (2020). Chilblain-like lesions on feet and hands during the COVID-19 Pandemic. *Int. J. of Derm.*, 1-5. doi:10.1111/ijd.14937

Lauer, S. A., Grantz, K. H., Bi, Q., Jones, F. K., Zheng, Q., & et al. (2020, May 5). The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Publicly Reported confirmed CAses: Estimation and Application. *Annals of Internal Med*. doi:10.7326/M20-0504

Leclerc, Q. J., Fuller, N. M., Knight, L. E., Funk, S., & Knight, G. M. (2020). What settings have been linked to SARS-CoV-2 transmission clusers? [version 1; peer review; 1 approved with reservations]. *Wellcome Open Research*. Retrieved from https://doi.org/10.12688/wellcomeopenres.15889.1

Lepelletier, D., Grandbastien, B., Romano-Bertrand, S., Ajp, S., Chidiac, C., Gehanno, J.-F., & Chauvin, F. (2020). What face mask for what use in the context of COVID-19 pandemic? The French guidelines. *J. of Hospital Infection*. Retrieved from https://doi.org/10.1016/j.jhin.2020.04.036

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., & et al. (2020). Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N. Engl. J. Med.* doi:10.1056/NEJMoa2001316

Liu, Y., Gayle, A. A., Wilder-Smith, A., & Rocklov, J. (2020). The reproductive number of COVID-19 is higher compared to SARS coronavirus. *J. of Travel Medicine, 27*(2). Retrieved from https://doi.org/10.1093/jtm/taaa021

Lloyd-Smith, J., Schreiber, S., Kopp, P., & et al. (2005). Superspreading and the effect of individual variation on disease emergence. *Nature, 438*, 355-359. Retrieved from https://doi.org/10.1038/nature04153

Lois, J. (2003). *Heroic Efforts: The emotional culture of search and rescue volunteers.* New York, New York: NYU Press.

Maritime and Coastguard Agency. (2020, May 12). *Guidance to IKSAR Responders - COVID-19 - Version 2.* Retrieved from Search and rescue framework (UKSAR): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/884971/UKSAR_COVID-19_v2_120520.pdf

Mizumoto, K., Kagaya, K., Zarebski, A., & Chowell, G. (2020). Estimating the asymptomatic proportion of coronavirus disease 2019 (COVID-19) cases on board the Diamond Princess cruise ship, Yokohama, Japan, 2020. *Eurosurveillance, 25*(10). Retrieved from https://doi.org/10.2807/1560-7917.ES.2020.25.10.2000180

Nishiura, H., Oshitani, H., Kobayashi, T., & et al. (2020). Closed environments facilitate secondary transmission of coronavirus disease 2019 (COVID-19). *Medrxvi*. Retrieved from https://doi.org/10.1101/2020.02.28.20029272

NPS. (2014, September 23). *2014*. Retrieved from Risk Calculator App: https://www.ncptt.nps.gov/blog/risk-spe-orma-and-gar-calculator/

Ontario Agency for Health Protection Promotion. (2020, March 6). *COVID-19 - What we know so far about routes of transmission.* Retrieved from Public Health Ontario: http://www.publichealthontario.ca/-/media/documents/ncov/wwksf-routes-transmission-mar-06-2020.pdf?la=en

OSHA. (2020). *Guidance on Preparing Workplaces for COVID-19.* US Department of Labor. Washington D.C.: US Department of Labor. Retrieved from https://www.osha.gov/Publications/OSHA3990.pdf

Paxton, N. C., Forrestal, D. P., Desselle, M., Kirrane, M., Bugden, S., Sullivan, C., . . . Woodruff, M. A. (n.d.). N95 Respiratory Masks for COVID-19: A Review of the Literature to Inform Local Responses to Global Shortages. Retrieved from https://research.qut.edu.au/biofabrication/wp-content/uploads/sites/62/2020/04/N95_COVID-19_LiteratureReview_2020_Submission.pdf

Peeri, N. C., Shrestha, N., Rahman, S., Zaki, R., Tan, Z., Bibi, S., . . . Haque, U. (2020). The SARS, MERS, and novel cornavirus (COVID-19) epidemics, the newest and biggest global helath threats: what lessons have we learned? *Int. J. of Epidemiology*. Retrieved from https://doi.org/10.1093/ije/dyaa033

PoliceOne.com. (2020, May 21). *COVID-19: Law enforcement deaths*. Retrieved from PoliceOne.com: https://www.policeone.com/coronavirus-covid-19/articles/covid-19-law-enforcement-deaths-3ftkdPnVffq55iHU/

Public Safety Canada. (2013). *Quadrennial Search and Rescue Review.* Ottawa: Canadian Government. Retrieved from https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/archive-nss-qdrnnl-rvw/index-en.aspx

Qian, H., Miao, T., Liu, L., Zheng, X., Luo, D., & Li, Y. (2020). Indoor transmission of SARS-CoV-2. *MedRxiv*. doi:https://doi.org/10.1101/2020.04.04.20053058

Ren, L. L., Wng, Y. M., Wu, Z. Q., Xiang, Z. C., Guo, L., Xu, T., & et al. (2020). Identification of a novel coronavirus causing severe pneumonia in humans: a descriptive study. *J. Chinese Medicine*. doi:10.1097/CM9.0000000000000722

Rodriguez-Morales, A. J., Cardona-Ospina, J. A., Gutierrez-Ocampo, E., Villamizar-Pena, R., Holguin-Rivera, Y., Escalera-Antezana, J. P., & et al. (2020). Clinical, laboratory and imaging features of COVID-19: A systematic review and meta-analysis. *Travel Med and Infectious Disease, 34*. doi:10.1016/j.tmaid.2020.101623

Rothan, H. A., & Byrareddy, S. N. (2020, May). The epidemiology and pathogenesis of Coronavirus disease (COVID-19) outbreak. *J. of Autoimmunity, 109*. doi:10.1016/j.jaut.2020.102433

Santarpia, J. L., Rivera, D. N., Herrera, V., Creager, H., Santarpia, G. W., & et al. (2020). Transmission potential of SARS-CoV-2 in viral shedding observed at the university of Nebraska medical Center. *medRxiv*. Retrieved from http://medrxiv.org/content/early/2020/03/26/2020.03.23.20039446.1.abstract

Schmidt, A. C., Sempsrott, J. R., Hawkins, S. C., Arastu, A. S., Cushing, T. A., & Auerbach, P. S. (2019). Wilderness medical Society Clinical Practice Guidelines for the Treatment and Prevention of Drowning. *Wilderness & Environmental Medicine*, S70-S86. Retrieved from https://doi.org/10.1016/j.wem.2019.06.007

Shereen, M. A., Khan, S., Kazmi, A., Bashir, N., & Siddique, R. (2020). COVID-19 infection: Origin, transmission, and characteristics of human coronaviruses. *J of Advanced Research, 24*, 91-98. Retrieved from https://doi.org/10.1016/j.jare.2020.03.005

Tindale, L., Coombe, M., Stockdale, J. E., Garlock, E., Lau, W. V., Saraswat, M., . . . Colijn, C. (2020). Transmission interval estimates suggest pre-symptomatic spread of COVID-19. *medRxiv*. Retrieved from https://doi.org/10.1101/2020.03.03.20029983

USCG. (2017). *Risk Calculation Worksheet - Calculating Risk Using GAR Model*. Retrieved from USCG: https://www.dco.uscg.mil/Portals/9/DCO%20Documents/National%20Strike%20Force/foscr/ASTFOSCRSeminar/Presentations/Safety/ORM-GAR.pdf?ver=2017-09-14-144539-427

van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., . . . Munster, V. J. (2020). Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *NEJM, 382*, 1564-1567. doi:10.1056/NEJMc2004973

Van Tiburg, C., Grissom, C. K., Zafren, K., Weber, D., Tremper, B., & Brugger, H. (2017). Wilderness Medical Society Practice Guidelines for Prevention and Management of Avalanche and Nonavalanche Snow Burial Accidents. *Wilderness & Environmental Medicine, 28*, 23-42. Retrieved from https://doi.org/10.1016/j.wem.2016.10.004

Vardavas, C. I., & Nikitara, K. (2020). COVID-19 and smoking: A systematic review of the evidence. *Tob. Induc. Dis., 18*. doi:10.1016/j.ijid.2020.03.017

Vardavas, C. I., & Nikitara, K. (2020). COVID-19 and smoking: A systematic review of the evidence. *Tob Induc Dis, 18*(20). doi:10.18332/tid/119324

Wang, W., Tang, J., & Wei, F. (2020). Updated understanding of the outbreako f 2019 novel coronavirus (2019-nCoV) in Wuhan, China. *J. Med. Virol*, 441-447. doi:10.1002/jmv.25689

WHO. (2020a). *Advice on the use of masks in the context of COVID-19.* Geneva: WHO. Retrieved from https://www.who.int/publications-detail/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-healthcare-settings-in-the-context-of-the-novel-coronavirus-(2019-ncov)-outbreak

WHO. (2020b). *Coronavirus disease (COVID-19) outbreak: rights, roles, and responsibilities of health workers, including key considerations for occupational safety and health.* Genea: WHO. Retrieved from https://www.who.int/publications-detail/coronavirus-disease-(covid-19)-outbreak-rights-roles-and-responsibilities-of-health-workers-including-key-considerations-for-occupational-safety-and-health

WHO. (2020c). *Infection prevention and control during helath care when novel coronavirus (NCoV) infection is suspected.* Geneva: WHO. Retrieved from https://www.who.int/publications-detail/10665-331495

WHO. (2020d). *Rational use of personal protective equipment for coronavirus disease (COVID-19).* Geneva: WHO. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE_use-2020.2-eng.pdf

WHO. (2020e). *Risk assessment and management of exposure of health care workers in the context of COVID-19.* Geneva: WHO. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/331496/WHO-2019-nCov-HCW_risk_assessment-2020.2-eng.pdf

WHO. (2020f, February 11). *WHO Direcotr-General's Remarks at the Media Briefing on 2019-nCoV on 11 February 2020*. Retrieved 2020, from WHO.int: https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020

Williamson, E., Walker, A. J., Bhaskaran, K., Bacon, S., Bates, C., Morton, C. E., & Curtis, H. J. (2020). OpenSAFETLY: factors associated with COVID-19-related hospital death in the linked electronic health records of 17 milliion NHS patients. *medRxiv*. Retrieved from https://doi.org/10.1101/2020.05.06.20092999

Yang, J., Zheng, Y., Gou, X., Pu, K., Chen, Z., Guo, Q., & et al. (2020a). Prevalence of comorbidities and its effects in the patients infected with SARS-CoV-2: a systematic review and meta-analysis. *Int. J. of Infectious Diseases, 94*. doi:10.1016/j.ijid.2020.03.017

Yang, J., Zheng, Y., Gou, X., Pu, K., Chen, Z., Guo, Q., & Zhou, Y. (2020b). Prevalence of comorbidities in the novel Wuhan coronavirus COVID-19) infection: a systematic review and meta-abaktsus,. *Int J. of Infectious Diseases., 94*, 91-95. Retrieved from https://doi.org/10.1016/j.ijid.2020.03.017

Young, C. S. (2020). The Paradigm Shift in Search and Rescue Response During the COVID-19 Pandemic in California. *Journal of Search and Rescue, 4*(2). Retrieved from http://journalofsar.com/issues/

Zheng, Z., Peng, F., Xu, B., Zhao, J., Liu, H., Peng, J., & Li, Q. (2020). Risk factors of critical & mortal COVID-19 cases: A systematic literature review and meta-analysis. *J of Infection*. Retrieved from https://doi.org/10.1016/j.jinf.2020.04.021

Appendix 1

COVSAR Guidelines