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SARS-CoV-2, COVID-19 & mountain sports: specific risks, their mitigation and recommendations for policy makers

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This paper has not yet been peer reviewed. We are circulating it now because of the immediacy of the current situation and a) to help mountaineers and hopefully politicians to develop concepts and b) to receive input from stake holders.

Abstract

SARS-CoV-2 is a coronavirus responsible for the COVID-19 pandemic that has affected all areas of life, including mountain sports. The aim of this review is to analyse the impact of SARS-CoV-2 and COVID-19 on mountain sports and to give best practice recommendations for mountain sports when there is a risk for a SARS-CoV-2 infection. SARS-CoV-2 can be transmitted via respiratory droplets and aerosols (floating liquid particles) generated during coughing, sneezing and talking as well as contact with SARS-CoV-2-contaminated surfaces. Most SARS-CoV-2 infections occur indoors, including one infection where a mountain walker probably became infected in her accommodation. In contrast, we found no reports of suspected SARS-CoV-2 infections during actual outdoor mountain sports, suggesting that the SARS-CoV-2 infection risk is low whilst pursuing these activities. The main transmission risks involve the associated activities including travel in gondolas, camping, stays in mountain huts or other accommodation and travel to and from mountain areas. These situations and settings carry the same risks as normal social activities, especially those involving crowded indoor environments with poor ventilation. We recommend a system to classify the risk of SARS-CoV-2 infection during a mountain sport or associated activity as either “high”, “moderate” or “low/negligible”. Based on these risk ratings, we provide a summary of measures that can be adopted to reduce the risk of SARS-CoV-2 infection during mountain sports or associated activities as well as recommendation of how to return to mountain sport after a SARS-CoV-2 infection.

1 Introduction

Infectious diseases have rarely been an issue for mountain sports, with the exception of mountaineering expeditions where infectious organisms can cause food poisoning or respiratory illnesses (Ericsson et al., 2001). This changed when the SARS-CoV-2 (severe acute respiratory syndrome coronavirus-2) coronavirus emerged into human populations in December 2019 (or possibly earlier based on wastewater analyses). The resulting COVID-19 (coronavirus disease 2019) pandemic caused many governments to impose unprecedented and costly mitigation measures in an attempt to bring the pandemic under control (Imperial-College-COVID-19-Response-Team, 2020b). In consequence, our daily lives and work have been profoundly affected. This includes participation in mountain sports such as hill walking (hiking), mountain running, bouldering, traditional climbing (self-placed protection), sport climbing (bolted climbs), winter climbing, and mountaineering in the Alps and the Greater Ranges. The COVID-19 pandemic has also affected travel to mountain areas and within the mountains, mountain rescue and mountain tourism.

In this review, we aim to answer the following four questions:

1) What are SARS-CoV-2 and COVID-19?
2) How is SARS-CoV-2 transmitted and what are the specific risks during mountain sports?
3) What COVID-19 mitigation measures that are related to mountain sports have been used in European and North American countries?
4) What are evidence-based recommendations on how to avoid SARS-CoV-2 infections especially during mountain sports?

2 What is SARS-CoV-2 and what is COVID-19?

In late 2019, a cluster of pneumonia cases of unknown cause was reported in Wuhan, China, and later attributed to a novel coronavirus termed SARS-CoV-2 (Bogoch et al., 2020; Zhou et al., 2020b). Since then, SARS-CoV-2 has swept around the world, and by mid-October 2020 the number of world-wide reported cases exceeded 35 million with over 1 million COVID-19-

related deaths. There is no sign of a decrease in the rate of new infections (John_Hopkins_University, 2020).

What is SARS-CoV-2 and how has is caused a pandemic?

The coronavirus that causes Covid-19 is known as SARS-CoV-2. It is thought to have originated in bats (**Figure 1**) and evolved the ability to infect humans, perhaps after intermediate passage through pangolin scaly anteaters (Bogoch et al., 2020; Petrosillo et al., 2020). Coronaviruses are widespread in nature and are characterized by having large single-stranded RNA genomes of approximately 30,000 nucleotides (Khailany et al., 2020). SARS-CoV-2 is the seventh coronavirus known to infect humans. Four of these only cause common colds. In contrast, the SARS-CoV-1 and MERS-CoV coronaviruses cause severe infectious diseases leading to deadlier outbreaks which, unlike COVID-19, could be brought under control (Petrosillo et al., 2020).

Why has COVID-19 turned into such a devastating pandemic whereas other the SARS and MERS outbreaks could be contained? Several features make SARS-CoV-2 dangerous:

1) The inherent infectivity of SARS-CoV-2 is sufficient to allow rapid exponential spread through a population (Read et al., 2020);
2) SARS-CoV-2 has an average incubation period of 5-6 days but it can be up to 14 days (Robert-Koch-Institut, 2020);
3) Many SARS-CoV-2-infected people (estimates go up to 80%) may never develop symptoms (Heneghan et al., 2020; Poletti et al., 2020) but such pre- or asymptomatic cases can nonetheless infect others. Maximal infectiousness has been estimated to be one day before the onset of symptoms (He et al., 2020; Rothe et al., 2020).
4) Whilst a SARS-CoV-2 infection is rarely a problem in healthy young people, the elderly and people with a number of underlying health conditions have a high risk of serious COVID-19 disease and death (Verity et al., 2020).

These factors combine so that infected but asymptomatic individuals can unknowingly transmit the virus to people in high risk categories who may suffer serious disease and over 10% of high risk patients may die (Li et al., 2020)(Williamson et al., 2020).

We will now discuss SARS-CoV-2 infectivity in greater detail. The inherent infectivity of a virus in an unmitigated situation is known as the basic reproduction number, R_0, which for SARS-CoV-2 is around 3 (Read et al., 2020). This is in the same range as respiratory syncytial virus and common cold coronaviruses (Spencer et al., 2020), much less than Measles (R_0 12 to 18; (Guerra et al., 2017)), but greater than seasonal influenza (R_0 ≈1.3) (Coburn et al., 2009; Guerra et al., 2017) and common cold rhinoviruses (Spencer et al., 2020). An R_0 value of around 3 equates to over 400 people becoming infected from an index patient over the course of a month if no mitigation measures are employed. If R_0 is reduced to below 1, then the number of infected cases will decline, as one infected individual infects on average less than one other person. The value of R_0 is an important indicator during the height of a pandemic and during subsequent, major waves, when community transmission levels are high. However, the R_0 value can be misleading after the outbreak has been brought under control and new infections may be confined locally e.g. in high risk employment settings such as food processing plants or hospitality venues. At that point the prevalence of the virus in the affected local communities becomes a more important factor than R_0 for deciding about mitigation measures such as local lockdowns. An example for a switch to local mitigation measures after the first wave in spring 2020 was the strategy of German states to apply mitigation measures including school closures or local lockdowns if the accumulated number of new cases over a 7-day period exceeds 35-50 per 100,000 population (Reintjes, 2020). Similar strategies are being employed in other European countries as case numbers rise in local hotspots.

What is the COVID-19 disease?

SARS-CoV-2 causes a respiratory infection by infecting the lining of the airways and this can cause COVID-19 disease with outcomes varying from no symptoms to death (Wölfel et al.,

2020). The majority of SARS-CoV-2-infected individuals under 60 years of age have no symptoms at least when tested (Poletti et al., 2020). Infected individuals with mild symptoms typically have a dry cough, fever and other cold-like symptoms, and loss of taste and smell are also common (Menni et al., 2020; WHO, 2020b). In more severe cases the SARS-CoV-2 infection extends from the upper respiratory tract down into the lungs, resulting in pneumonia and sometimes severe lung damage, necessitating intensive care treatment with supplementary oxygen. In the most severe cases an over-active inflammatory response caused by a “cytokine storm” which can lead to multiple organ failure combined with severe pneumonia and death (Zhou et al., 2020a).

The impact of Covid-19 of course comes from the ever-increasing global death toll. The number of people who die as a result of a viral infection can be represented by the case fatality rate (abbreviated CFR which is deaths per diagnosed infections). One estimate of the case fatality rate for SARS-CoV-2 is 1.38% overall, 8.6% for people in their 70s and 13.4% for those aged 80 or more. In comparison, the case fatality rate for seasonal influenza is over 10 times lower, around 0.1% overall, rising to 0.8% for those over 65 (Ruan, 2020). The estimation of case fatality rate depends, however, on the extent of testing for the virus in the community. The infection fatality rate for SARS-CoV-2 (abbreviated as IFR, an estimate of the death rate of all infected individuals independent of the degree of testing) has been estimated to be 0.5-1% (Mallapaty, 2020). Emerging COVID-19 treatments will reduce COVID-19 case fatality and infection fatality rates.

To put the fatality risk of COVID-19 into context, using reliable data from an example country, the average annual death toll from influenza in England during the years 2015 to 2019 was 12,000 (varying from 4000 to 22000), with the vast majority of these in the over 65 age group (Public_Health_England, 2020b). In comparison, 37,000 deaths attributed to COVID-19 after a positive test have occurred in England up to August 2020 (Public_Health_England, 2020a). Thus COVID-19 has from March to August 2020 caused more than 3-times as many deaths in

England than the flu in average year. The relative degree of fatality risk from COVID-19 has been partially masked by the fact that mitigation measures have reduced exposure such that by October 2020 only 6 to 7% of the population in England had been infected (Office_for_National_Statistics, 2020a). Therefore, left unchecked, COVID-19 has the potential to cause many times more deaths than have occurred to date. Thus COVID-19 is clearly a more serious disease than the flu.

The overall case fatality and infection fatality rates for SARS-CoV-2 do not reveal factors that greatly influence the risk for severe COVID-19 and COVID-19 related death. The most marked of these is age. The number of deaths of those under 40 is low, while for those in their 70s and 80s the risk has been estimated as over 20-fold and about 80-fold higher, respectively, than those in their 40s and even more so than in those in their 20s (Williamson et al., 2020). For example, in the UK 74% of all COVID-19 attributed deaths have been of people aged 75 and over, 90% aged 65 and over. This can be relevant for assessing the risk of mountain sports when practiced by younger mountaineers. However, many mountaineers are in the older age groups and they may be more likely to participate in higher COVID-19 risk activities such as travel in gondolas or mountain hut stays.

Within all age groups, most victims have at least one underlying health condition. Such health conditions are respiratory problems (but surprisingly not asthma, compared to the overall death rate of those in their 50s), a compromised immune system, obesity, diabetes, heart disease and dementia (Williamson et al., 2020). The risk is also increased in males, blood group A carriers (Ellinghaus et al., 2020), is linked to ethnic origin as well as occupation and socio-economic circumstances (Williamson et al., 2020). The occupational risk may be to a major extent due to the degree of social contact inherent in that occupation (Office_for_National_Statistics, 2020b). In summary, whilst there are many risk factors for a severe course of COVID-19 disease and death, by far the greatest risk factor is being older than 70 years.

What drugs and vaccines are available or under development for Covid-19 treatment?

At present, two drugs have been licensed for clinical use to treat patients with severe COVID-19: remdesivir, a drug that inhibits the ability of SARS-CoV-2 to produce new virus, and dexamethasone which is a cheap and widely available corticosteroid, also used to treat acute high altitude sickness, that reduces the uncontrolled inflammatory response which is the cause of death in many instances. These drugs have been shown to reduce the length of time of hospital stay (remdesivir; (Beigel et al., 2020)) and reduce the death rate in patients requiring supplementary oxygen (dexamethasone; (Horby et al., 2020)). A note of caution concerning the effectiveness of remdesivir comes from a recent WHO study that found it had no beneficial effect on mortality rates (https://www.medrxiv.org/content/10.1101/2020.10.15.20209817v1). More encouraging news comes from the development of humanised monoclonal antibodies that inactivate SARS-CoV-2 which are now in clinical trials (for example those produced by Regeneron Pharmaceuticals: https://www.regeneron.com/covid19).

Several vaccines are in clinical trials. A vaccine that protects against future infection would be ideal, but even one that reduces the severity of disease would be highly beneficial. As infected patients produce antibodies that target the so-called spike protein of SARS-CoV-2 which is required for infection (Walls et al., 2020), an effective vaccine is possible in principle. Although the levels of anti-viral antibodies decline with time (Seow et al., 2020), residual immunity may be sufficient to provide some protection. There are early indications that some candidate vaccines induce an immune response that may be protective (Folegatti et al., 2020; Jackson et al., 2020; Robbiani et al., 2020; Yang et al., 2020).

3 How is SARS-CoV-2 transmitted in-between humans and what are the specific risks during mountain sports?

SARS-CoV-2 mainly transmits via three routes which are respiratory droplets, respiratory aerosols (also described as airborne transmission) and via contaminated surfaces (also known as fomites, i.e. inanimate objects; see **Figure 1**). In this section we will discuss these routes of transmission and the general mitigation measures that can be adopted. SARS-CoV-2 infects the cells of the lining of the respiratory tract (Wölfel et al., 2020). These cells then produce large amounts of new virus particles which are excreted into the fluids that line these airways, i.e. mucus and saliva. An infected person may expel between 1,000 and 100,000 copies of the virus per minute from the mouth (Ma et al., 2020) although it is unclear how much of that virus is infectious. The virus that is released may be contained within large droplets (>5 μm) that sink to the ground or onto surfaces within ≈1 m (Bourouiba et al., 2014), or via aerosols (droplets ≤5 μm) that float and can accumulate, especially in indoor spaces with poor ventilation (Buonanno et al., 2020; Robert-Koch-Institut, 2020). Droplets and aerosols are produced not only during coughing and sneezing (Bourouiba et al., 2014) but also during talking, especially when talking loudly (Asadi et al., 2019). Airborne droplets of any size may directly infect an individual if they reach the mouth, nose or eyes.

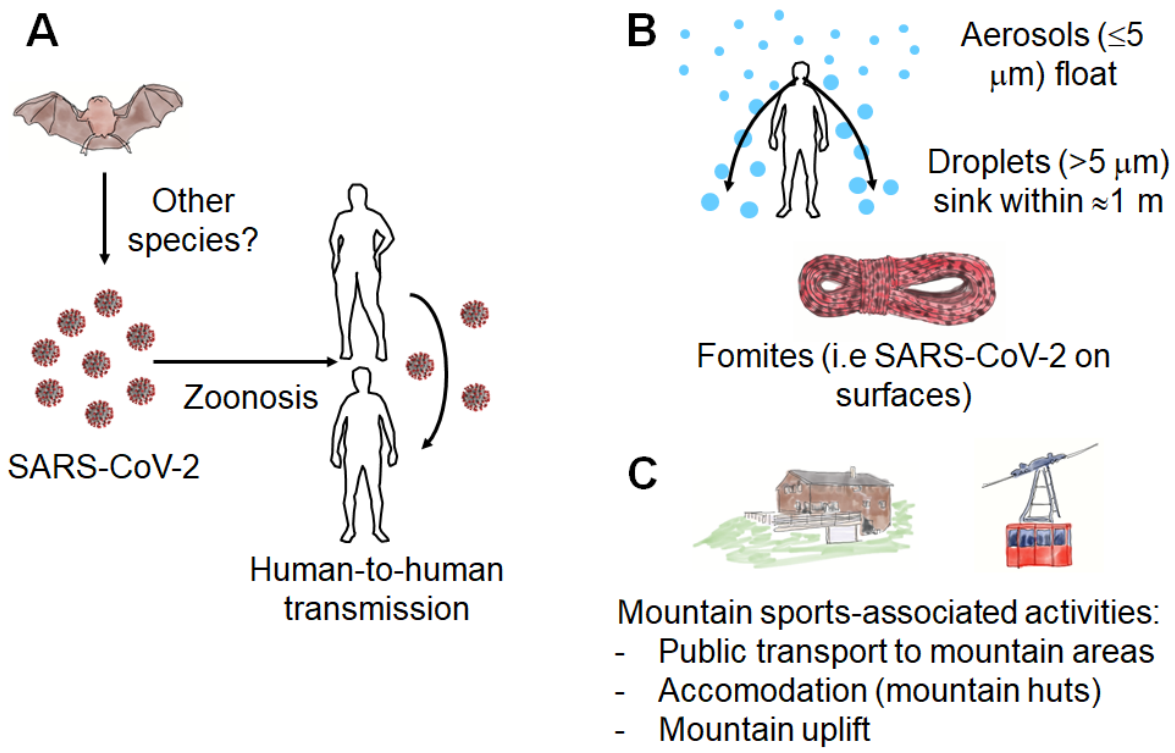

Figure 1. **A** SARS-CoV-2 probably has transmitted from bats possibly via another species to humans and since 2019, human-to-human SARS-CoV-2 infections occur. **B** Human-to-human SARS-CoV-2 infections can occur via respiratory droplets, that sink to the ground within ≈1m or tiny aerosols that float in the air and can accumulate in small, poorly ventilated indoor venues (probably no risk outdoors). Additionally, SARS-CoV-2 can be transmitted via commonly used equipment such as climbing equipment. **C** The risk of a SARS-CoV-2 infection is generally low during outdoor mountain sports (see next section) but risks exist during mountain sports-associated activities such as public transport to mountain areas, accommodation in tents or mountain huts and during mountain uplift.

Infections via contaminated surfaces can occur if droplets from an infected individual are deposited on surfaces. Touching of such surfaces by an uninfected individual, who in turn touches their mouth, nose, or eyes, can lead to a SARS-CoV-2 infection. SARS-CoV-2 can remain viable on surfaces such as plastic for up to 72 h (Rabenau et al., 2005; van Doremalen et al., 2020), depending on the amount of virus, the surface, and ambient humidity. The virus particle will lose infectivity if dried out, but in principle the virus could remain active for longer than 72 hours if contaminated droplets do not evaporate (van Doremalen et al., 2020). The nature of a contaminated surface is a factor here, for example soft items of mountaineering equipment may constitute less of a risk than a worktop in a mountain hut. The risk of infection via contaminated surfaces can be reduced by cleaning, frequent hand washing, and the use

of hand sanitisers. Soap and standard disinfectants rapidly inactivate SARS-CoV-2 (Chin et al., 2020), so the virus is easy to destroy.

The WHO initially emphasized SARS-CoV-2 transmission via droplets as a major route of transmission but has now acknowledged that airborne infections via aerosols are likely. The fact that most infections (Qian et al., 2020) and superspreader events (during which at least 5 others are infected by an index patient) occur indoors in situations where there is not always a close contact between infected individuals (Swinkels, 2020) suggests that indoor aerosol-mediated SARS-CoV-2 outbreaks are a major factor in the COVID-19 pandemic (Morawska and Milton, 2020).

Given these routes of virus transmission, specific mitigation measures and protective equipment can be used to reduce transmission via droplets, aerosols or surfaces. These are equally applicable to society in general and mountain sports. The greater the distance between people the less chance there is of direct transmission of the virus through large respiratory droplets, particularly if face-to-face orientation is avoided and if we are silent or talk quietly. Aerosols can travel far greater distances than droplets but will be rapidly diluted by good ventilation, particularly outdoors. This will reduce considerably the chance of outdoor virus transmission. It follows that the situations involving large numbers of people closely packed in poorly ventilated indoor environments pose hugely increased risks compared to outdoor mountain-related settings. For example, one study found only one instance of outdoor transmission in over 318 analysed infection events (Qian et al., 2020) and generally outdoor transmissions are rare among over 1400 superspreader events (Swinkels, 2020). The factors involved in this relatively low risk outdoors include rapid dilution of aerosols, easier social distancing, and inactivation of the virus through drying and sunlight through UV radiation. For example, aerosols containing the virus lose 90% of infectivity within 6 minutes in sunlight, twenty times faster than in darkness (Schuit et al., 2020). The effect at altitude should be larger

as UV radiation increases with altitude (Schmucki and Philipona, 2002). Thus, the risk of a SARS-CoV-2 infection during outdoor mountain sports is probably small.

Advice on face masks has evolved over the course of the pandemic. In many countries face masks are now recommended or obligatory especially in situations where social distancing is difficult or impossible such as on public transport or whilst shopping (CDC, 2020; Howard et al., 2020)). The principal objective of the use of a face mask is to contain any infected droplets and aerosols that an infected person may release. Also face masks will reduce the SARS-CoV-2 dose to which a non-infected person will be exposed, and this may increase the percentage of asymptomatic cases and reduce COVID-19 severity (Gandhi and Rutherford, 2020). In principle therefore, face masks reduce the risks of all three major forms of potential virus transmission if they are worn correctly with a good fit covering both mouth and nose.

Whilst there is abundant evidence that most face masks filter particles and protect from a SARS-CoV-2 infection (Howard et al., 2020), there are caveats. Particularly early in the pandemic, a shortage of surgical face masks led to the adoption of home-made or commercial versions made of a variety of common fabrics. Recent research has demonstrated that some types in common use (for example fleece, bandana-type or single layer simple fabrics) reduce droplets and aerosol by only a small amount (Fischer et al., 2020). Another substantial issue is that droplets containing the virus will accumulate within the mask of an infected person. If they repeatedly touch, remove and replace the same mask they will inevitably get virus on their hands which can be theoretically transferred to others. To be maximally effective e.g. in situations where the risk of a SARS-CoV-2 infection and serious consequences is high, face masks should be used and disposed of correctly and carefully, and not taken on and off repeatedly. In summary, social distancing is the best policy to avoid droplet and aerosol infections but when social distancing is difficult or impossible as e.g. during public transport, mountain uplift, whilst moving in a mountain hut or whilst sharing a cramped belay and talking

for extended periods while others climb, mountaineers should wear face masks if the overall or individual SARS-CoV-2 infection risk is moderate to high.

The three routes of SARS-CoV-2 transmissions, the risks during mountain sports and suitable mitigation measures are summarized in **table 1**.

Table 1. Specific risks during mountain sports

Transmission route	What are the risks during mountain sports?	How can the risk be mitigated?
1 Droplets Larger (>5 μm) respiratory droplets that sink to the ground within ≈1 m	- Close distance e.g. whilst belaying or during mountain rescue - Talking during instruction and guiding	- Distance by more than 1.5 or 2 m - Face masks (Kähler and Hain, 2020) if distancing is not possible e.g. on belays, whilst spotting or during mountain rescue
2 Aerosols Tiny (≤5 μm), floating, respiratory droplets that can travel esp. indoors	- Low risk during mountaineering itself - Risk in cable cars, mountain huts, travel to the mountains or rescue helicopters	- Minimal risk during outdoor mountain sports - High ventilation in small indoor spaces such as gondolas or mountain huts
3 Surfaces (fomites) SARS-CoV-2 on surface droplets can cause surface-hand-mouth/nose infections	- Actual danger during mountain sports is unclear and may be low - Jointly used equipment (especially with solid surfaces, or if placed in the mouth) - Rock holds during climbing - Mountain rescue scenarios	- Disinfection through hand washing or use of hand sanitiser - Face masks also prevent touching mouth and nose - Do not put any equipment in the mouth

(Robert-Koch-Institut, 2020; WHO, 2020a)

4 Is there any evidence for suspected SARS-CoV-2 transmissions during mountain sports?

To identify suspected SARS-CoV-2 transmissions during mountain sports, we searched the scientific literature and the internet about reports of such transmissions (see supplementary data for detail). Additionally, we have contacted mountain sports-related associations in the USA, Canada, Germany, Austria, Switzerland, England and Scotland to ask about suspected

SARS-CoV-2 infections during actual mountain sports or in situations related to mountain sports. These searches yielded no suspected transmissions apart from one outbreak which was mentioned in a response by the German Alpine Club (DAV). The outbreak is described on a German-speaking website, here translated into English:

"In June, two women decided to go on an alpine mountain walk from Oberstdorf through Tyrol to Meran in South Tyrol. After returning from the hike, one of the two walkers from the Memmingen area of Bavaria tested positive for the coronavirus. The authorities then immediately began to trace the women's contacts and have so far been able to track down 5 more infected persons in the district of Landeck. Most of these are said to be members of the host family of a private accommodation […] *The walkers had stopped off in Tyrol in five huts or lodgings to spend the night there."* (Unknown, 2020).

Whilst this is anecdotal, the fact that only one of the two women became infected during the first half of the walk (Landeck is less than half distance between Oberstdorf and Meran) suggests that the walking itself was low risk because otherwise both women would have tested SARS-CoV-2-positive during the ≈140 km walk. Based on the circumstances it seems likely that the one woman became infected in accommodation, highlighting again that indoor spaces are the major setting where SARS-CoV-2 infections take place (Qian et al., 2020; Swinkels, 2020).

5 How have different countries regulated mountain sports during the COVID-19 pandemic?

After the first cases in Wuhan in December 2019, SARS-CoV-2 rapidly spread around the globe which is primarily explained by global travel of infectious, asymptomatic individuals that then meet and infect others at their destination (Rothe et al., 2020). Here, we compare and contrast COVID-19 responses especially in relation to mountain sports in the USA, Canada, UK, Germany, Austria, and Switzerland. In these countries, the first confirmed SARS-CoV-2

infections were on 20.1.2020 in the USA, 25.1.2020 in Canada, 27.1.2020 in Germany, 31.1.2020 in the UK (1.3.2020 in Scotland), 8.2.2020 in Austria, and 25.2.2020 in Switzerland (data are from the Wikipedia texts on COVID-19 in these countries. Accessed in September 2020). Additionally, we describe the stance of the UIAA in relation to COVID-19 and mountain sports.

After the first SARS-CoV-2 infections in January and February 2020, numbers of SARS-CoV-2 infected people often rose exponentially. At that time in March, researchers modelled the future numbers of SARS-CoV-2-infected individuals and COVID-19 deaths worldwide. In the most notable analysis, an Imperial College team estimated that up to 90% of the total world population could become infected with SARS-CoV-2 and that 40 million people would die in 2020 alone if no mitigation measures were adopted (Imperial-College-COVID-19-Response-Team, 2020a). Based on this and other modelling analyses, countries or the states and provinces within these countries then implemented often drastic and costly mitigation measures, also termed non-pharmaceutical interventions, to reduce a further exponential rise of COVID-19 cases and deaths which threatened to overwhelm national health systems in the Spring of 2020 (Imperial-College-COVID-19-Response-Team, 2020b; Sebhatu et al., 2020). The restrictions were introduced during March 2020 then maintained for variable periods (Sebhatu et al., 2020). These interventions included lockdowns, closure of childcare, schools and universities, transport restrictions, closure of the hospitality sector and non-essential retail outlets and instructions to work from home. After debates about their effectiveness, the wearing of face masks became mandatory in specific situations such as indoor shopping or public transport in most countries from April 2020 onwards. However, COVID-19-related issues such as wearing face masks became politicized especially in the USA and elsewhere (He and Laurent, 2020). The politicization of COVID-19 and fake news (Naeem and Bhatti, 2020) and anti-Corona demonstrations became new challenges for the management of COVID-19. Moreover, the enormous economic and social damage caused by mitigation measures such

as general lockdowns initiated a debate on whether the cost of the mitigation measures is justified by the years of life saved (Miles et al., 2020).

Here, we will briefly review the course of the national COVID-19 situation so far and then we will compare and contrast especially those related recommendations, rules and laws in USA, Canada, Germany, Austria, Switzerland, and the UK that are relevant for mountain sports. Table 2 gives some data for key events in these countries. It is important to note that the COVID-19 pandemic is continuously evolving, with no indication in October 2020 that the increases in worldwide cases and deaths are diminishing. Indeed, at that time many European countries are experiencing a renewed and severe resurgence of the virus, with the outcome of the pandemic over the winter of 2020/2021 very uncertain. This situation, and consequent continuing and re-imposition of restrictions on social activities, will continue at least until a vaccine becomes available.

Table 2. COVID-19 mitigation measures in the countries surveyed.

Country	Case-based self isolation	Social distancing encouraged	First, major lockdown start & end dates	Public events banned
USA/states	31.01.2020 (Riechmann, 2020)	13.03.2020 (Liptak, 2020)	Variable. 19/24.3.-13.4./13.6.2020 (Bacon and Ortiz, 2020; California_all, 2020; Homeland_Security, 2020)	15.03.2020 (Kopecki, 2020)
Canada/states	02.02.2020 (Rodriguez, 2020)	12-23.03.2020 (Canadian_press, 2020)	14.03.2020-24.04.2020 (Government_of_Canada, 2020)	23 - 22.03.2020 (CCLA, 2020)
Germany*	6.3.2020	12.3.2020	23.3.-20.4./10.5.2020	20.3.2020
Austria*	16.3.2020	16.3.2020	16.3.-13.4.2020	10.3.2020
Switzerland*	2.3.2020	16.3.2020	20.3.2020	14.3.2020
UK*	12.3.2020	16.3.2020	23.3.2020	24.3.2020

*Information from (Imperial-College-COVID-19-Response-Team, 2020b). In the USA, Arkansas, Iowa, Nebraska, North Dakota, South Dakota and Wyoming did not lockdown. Other information was taken from national COVID-19 entries on Wikipedia. Identified cases and their contacts in the UK were quarantined from the end of January onwards, as were those returning from visits to high risk countries or locations.

To compare and contrast mountain sport-related recommendations, rules and laws in USA, Canada, Germany, Austria, Switzerland, and the UK (both England and Scotland), we have searched for such information by contacting mountain sports and mountain rescue associations in these countries and/or have retrieved information from government and association websites (see supplementary data). We will now discuss the mountain sports-specific regulations for these countries.

USA. The United States had an arguably chaotic response to COVID-19. Early travel restrictions were put in place from countries including China and Iran however it was not until mid-March that the US boarder was closed to non-essential travel. There was no national stay-at-home order but many individual states did enact various combinations of stay-at-home, social distancing, and/or mask requirements. Initial effects on climbing and mountaineering activities were mostly related to state stay-at-home orders that prevented climbers from

travelling to smaller mountain towns. On the 17.3.2020 the American Alpine Club advised climbers to avoid climbing outside their community and potentially burdening already overwhelmed health care systems. All huts were closed through 8.5.2020. The American Mountain Guide Association did not issue any specific suggestions to their members to reduce likelihood of infection. However, all guide training programs were postponed to 10.8.2020.

US National Parks were closed in March and gradually reopened throughout the summer (park by park). Users were recommended to stay close to home and follow regional health guidelines in addition to 2 m social distancing rules. State and local park closures varied by location. The North West Avalanche Centre and the Colorado Avalanche Information Centre both stopped issuing forecasts around 27.3.2020 due to local stay-at-home orders and to encourage activity that do not burden the medical system. Despite a resurgence in cases in some states in the month of August, mountain activities continue with most parks open and guide services operating.

Canada. A federal travel restriction was put in place on 18.3.2020, shortly after the United States that reduced international and North American travel significantly. Anyone entering Canada, including citizens, had to self-quarantine for 14 days. Within Canada, COVID-19 policies varied regionally with areas unable to support high infection numbers closing completely and most of the country under some sort of stay at home order. Services in many areas such as public transit were reduced, while protocols in stores and restaurants were revised to allow for 2 m social distancing or mask use.

Alpine Club of Canada huts were closed initially through 12.6.2020 with major changes to their protocols such as single group bookings for the entire hut as well as minimum time period between bookings. Initially, climbing and mountaineering activities in Canada were discouraged with both Provincial and National Parks closed, but by 1.6.2020, the National Parks reopened and Provincial Parks reopening throughout the summer. The initial stoppage

in activity was encouraged by Avalanche Canada, who stopped issuing public avalanche bulletins in March. Many mountain towns in Canada were somewhat insulated from the effects of COVID-19 by their remote nature.

With most activities and areas reopen by July 2020, 2 m social distancing or the wearing of masks was the primary recommendation. Some more popular areas have been hit with new restrictions limiting the number of visitors. The Association of Canadian Mountain Guides gives a number of recommendations beyond the use of masks to minimize contact between guides and clients.

Germany. Despite having the first cases in late January (Rothe et al., 2020), Germany has managed to keep SARS-CoV-2 infections and COVID-19 deaths relatively low whilst allowing outdoor sports and a return to near-normal mountain sports from June/July 2020. To avoid overwhelming the health system as well as an exponential increase of SARS-CoV-2 infections and COVID-19 deaths, Bavaria declared a curfew on the 20.03.2020 followed by a federal, nationwide curfew from the 23.03.2020. These lockdown measures were then eased from the 20.04.2020 onwards. Individual outdoor exercise with social distancing of at least 1.5 m was permitted throughout the curfew but the government discouraged non-essential travel including travel to mountain areas.

To guide post-lockdown mountain sports, German mountain sports associations issued recommendations. To lower the SARS-CoV-2 infection risk the German Alpine Club (DAV) recommends undertaking mountain sports only in permissible group sizes, social distancing during sport of at least 2 m or face masks when this is not possible. Furthermore it suggests avoiding contact rituals such as hand shaking. First aid should be delivered normally but with a face mask. In addition to these general recommendations, the DAV recommends additional, specific measures for climbing, bouldering and mountain biking (German_Alpine_Club, 2020b). Presumably informed by a pre-print that recommended long distances during locomotion

(Blocken et al., 2020), the DAV recommends a distance of 20 m for downhill or flat mountain biking (German_Alpine_Club, 2020b). Given that we are not aware of any SARS-CoV-2 infections during cycling and that there are few outdoor transmissions (Qian et al., 2020; Swinkels, 2020) such extreme distancing seems excessive.

The association of German mountain and ski guides (VDBS) issued hygiene recommendations for groups of up to 10 people. The guidelines recommend 1.5 m distance e.g. during a partner check when climbing and a face mask or e.g. neck gaiter mouth and nose on a belay (VDBS, 2020). Generally the VDBS rules are less restrictive than the DAV rules. Since the 17.6.2020, mountain huts in Bavaria allow up to 10 people to sleep within one room without social distancing (German_Alpine_Club, 2020a). Given that many SARS-CoV-2 infections occur indoors, the risk of infection seems high should an infected individual share a room with others especially if the room is small and poorly ventilated (Buonanno et al., 2020).

Austria. Despite SARS-CoV-2 superspreader events during the late skiing season 2020 and despite neighbouring Italy, which had a major outbreak in spring 2020, Austria had comparatively low cases and deaths and has permitted near-normal mountaineering activities from June/July 2020. Skiing holidays in Austria, most notably Ischgl, had a major role in spreading SARS-CoV-2 in Europe and beyond. It seems likely that it was not the skiing itself, but apres-ski activities, hotels and travel from a skiing holiday in a resort with many SARS-CoV-2 infected individuals were responsible for the majority of skiing-related infections in Spring 2020 (Karnitschnig, 2020). Austria then introduced a lockdown on the 16.3.2020, several days earlier than neighbouring Germany but also started to ease lockdown rules comparatively early, from the 13.4.2020 onwards. The Alpine Club Austria (ÖAV) has regularly posted mountain sports-related COVID-19 news on their website which included recommendations not to participate in ski touring or mountaineering during the March and April lock down. On the 02.07.2020 the ÖAV issued 8-point-guidelines for COVID-19 and mountaineering. These included recommendations to go mountaineering only when healthy, 1

m distancing (most other nations recommend 1.5 or 2 m), small group mountaineering, contact avoidance, the following of hygiene rules, normal first aid and special rules for mountain huts (Alpenverein_Österreich, 2020).

Switzerland. The federal government of Switzerland (Bundesrat) declared an extraordinary situation according to the epidemics law and imposed major restrictions from the 16.03.2020 until the 19.04.2020. Mountain sports were never stopped completely although early in the pandemic it was encouraged to avoid especially dangerous activities and tours. More recently, mountain sport has experienced a boom. Alpine club huts were temporarily closed and mountain guides were stopped from working between 19.3.2020 and 8.6.2020, enforced by a suspension of insurance coverage. These recommendations were made in part to protect hospitals and intensive care units from unnecessary accident victims. The Swiss Alpine Club (SAV) lists on its website up-to-date COVID-19 recommendations and rules for mountain sports, mountain huts and indoor climbing that are based on general Swiss COVID-19 recommendation by the federal health office (Schweizer_Alpenverein, 2020). Basic rules are relatively simple and include no mountain sports for individuals that suffer from COVID-19 symptoms as well as usage of hand sanitizer/disinfectant and face masks in addition to recording the names of the members of climbing parties. Registration for overnight stays is also required. Mountaineering training courses have taken place since the 08.06.2020 (Schweizer_Alpenverein, 2020).

United Kingdom. The first cases of COVID-19 in the UK were detected in late January 2020. As a result of high levels of international travel, particularly to highly infected regions of Italy, Spain and France, there were at least 1300 separate introductions of the virus during February and March, each leading to an infection cluster (Pybus et al., 2020). Coupled with a high population density in much of England and the Central Belt of Scotland, and other social and demographic factors, this has resulted in a relatively high death toll in the UK, similar to that of other hard-hit European countries such as Spain, Belgium and Italy. The time course and death

rates in the different nations of the UK have been similar, with Northern Ireland being the least affected. This is despite aspects of the lockdown including a stringent travel restriction being maintained for several weeks longer in Scotland than in England.

Lockdown in the UK was introduced in stages, with major limitations on social interactions and economic activity beginning on 15.03.2020 and full lockdown enforced a week later. Mountain sport organisations began closing their huts and stopping all Meets from 15.03.2020. Government enforcement of strict travel restrictions on 23.03.2020 called a halt to all mountain sport activities throughout the UK. These restrictions remained in place in all parts of the UK until mid-May when the UK Government started a gradual easing, beginning with lifting of travel restrictions. This allowed a resumption of mountain sports in England, although in Scotland the travel restriction remained in place until 05.07.2020. In Scotland, provided the activities remained within the 8 km travel restriction, hill walking, bouldering and top-roping were allowed from 29.05.2020, and rock-climbing from 19.06.2020. Mountaineering clubs in England started to re-open their hut accommodation in a very limited manner from mid-June 2020 although many remain closed in Scotland even into October 2020. The hospitality industry was allowed to fully re-open in England at the beginning of July, with Scotland following suit two weeks later. The easing measures has had no detrimental effect on the numbers of deaths and hospitalisations up until early September 2020, and the differences in policy between England and Scotland has not resulted in any major differences in the development of the epidemic in the two nations. At the start of September however, in common with many other European countries, the rates of infection have begun to increase again markedly. Although this has initially been largely confined to young people, there is a realistic fear that death rates will begin to rise again throughout Europe over the Autumn and Winter 2020/2021.

Apart from differences in timing caused by government policy variations, the mountaineering organisations within the UK have adopted very similar advice on minimizing the risk of transmission of the virus, notably 2 m social distancing, good hand hygiene, avoidance of

public and shared transport and crowded areas, and the use of face masks in enclosed spaces when social distancing is not possible (see for example (BMC, 2020a, c; Mountaineering-Scotland, 2020). Those Clubs that have re-opened their huts have limited occupancy to no more than one or two households with 72 h between bookings to allow time for any virus to be inactivated (see British Mountaineering Council guidelines (BMC, 2020b).

The UIAA response. Globally the Union Internationale des Associations d'Alpinisme (UIAA; International Climbing and Mountaineering Federation) as an umbrella organization for national mountaineering organisations, has established an UIAA Covid-19 Crisis Consultation (CCC) Taskforce and dedicated webpage (UIAA, 2020). The mission of the CCC Task Force is to establish a group of members and experts to provide quick responses to queries from countries and member associations around the world. During the early stages of the COVID-19 pandemic, there was little scientific evidence on how to deal with SARS-CoV-2 but the UIAA wanted to be able to provide swift answers, mainly by promptly referring the questions for consultation to a government authority, to a crisis management body, to a competent national federation or to a relevant UIAA commission. The UIAA has additionally thus put in place its own, lean, Covid-19-crisis-related body which is the aforementioned UIAA Covid-19 Crisis Consultation (CCC) Taskforce. The aim of the task force is to answer COVID-19-related queries quickly to support its members. The taskforce had operated via videoconferences and gathered COVID-19-related inputs and information from different parts of the world ranging from the Alps to the Himalayas. It provided a forum for discussing COVID-19 related issues and has published relevant COVID-19 information on its webpage (UIAA, 2020).

6 COVID-19 & mountain sport recommendations

In this final section we anticipate and answer questions linked to mountain sports, SARS-CoV-2 and COVID-19 to inform mountaineers, mountain sports associations and policy makers. As a general point in terms of overall government policy making, we note that a technical report issued by the European Centre for Disease Prevention and Control states that: "Stay-at-home

measures are a last-resort option due to their significant impact on both society and individuals. Targeted implementation, both geographically and temporally, is preferred and can be considered to control outbreaks which are not responding to other measures. Available evidence does not prove that stay-at-home measures are more effective than other measures, such as the closing of (some) high-risk businesses" (ECDC, 2020).

Question 1: How to assess the risk of a SARS-CoV-2 infection during a mountain sport activity and its consequences?

Background. Mitigation measures should be proportional to the actual risk of a SARS-CoV-2 infection and its consequences such as a severe course of COVID-19 or death or the risk of overwhelming the health service. Here, we propose a rating system of how to assess the risk of a mountain sports activity including related activities.

Recommendation. Risk assess your planned mountain sport activity and plan mitigation measures following the flow chart illustrated in **Figure 2**. We recommend to classify overall risk based on the questions below.

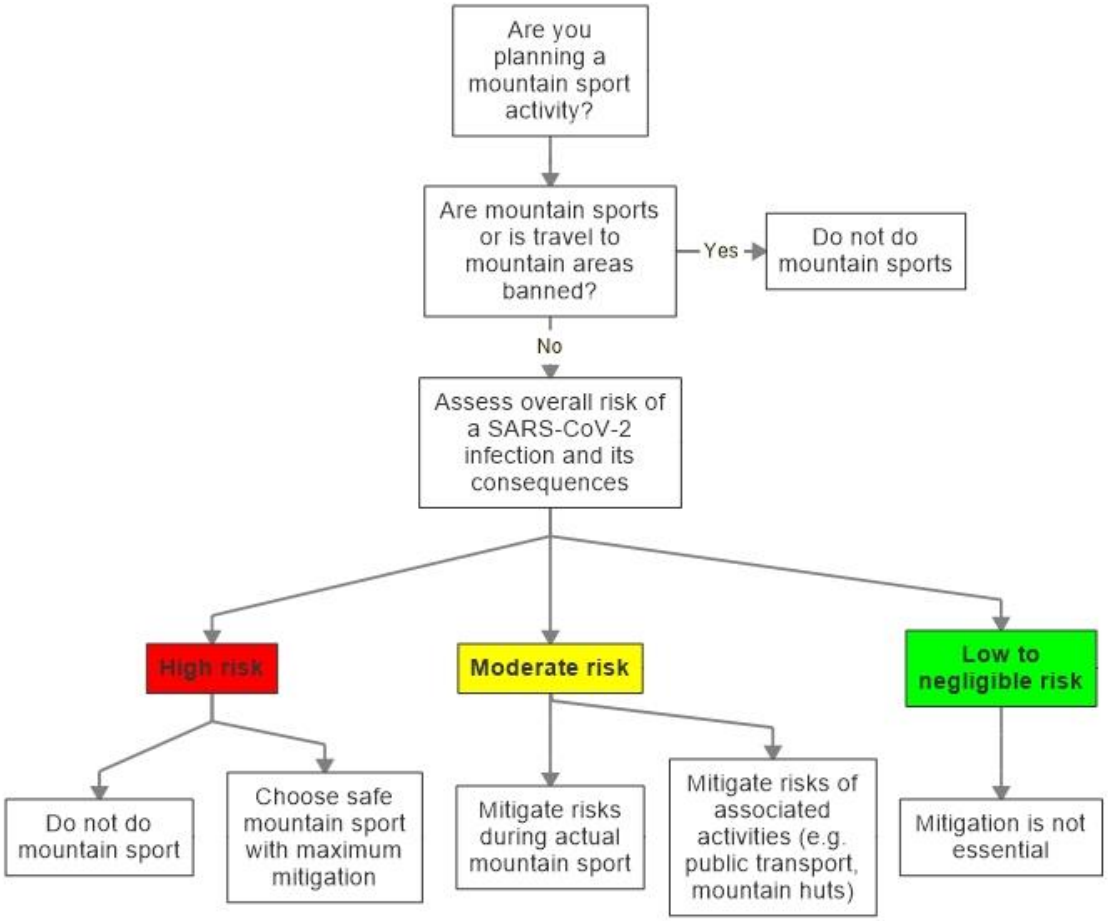

Figure 2. Flow chart illustrating a mountain sport-specific risk assessment and recommended mitigation measures.

To assess the overall risk of a SARS-CoV-2 infection and of its consequences, we have developed four questions and a scoring system that aims to help to assess the risk of becoming SARS-CoV-2 infected during a mountain sports activity and of suffering a severe course of COVID-19 or of dying. Nonetheless, it is important to bear in mind that mortality is not the only risk of COVID-19. Many SARS-CoV-2 infected individuals continue to suffer from COVID-19-related symptoms such as fatigue or dyspnea (breathlessness) for >1 month after their infection has passed. This is known as “long COVID” (Carfì et al., 2020; Mahase, 2020; Weerahandi et al., 2020). The questions and possible answers are listed below. Choose the answer that best answers the question (i.e. not all items need to be precise).

A: How high is the general risk of a SARS-CoV-2 infection and how severe are the consequences of an infection?

High (10). Community transmission (inability to relate confirmed cases through chains of transmission); ≥/50 new SARS-CoV-2 cases per 100,000 inhabitants per week; SARS-CoV-2 tests positivity ≥5% of SARS-CoV-2; SARS-CoV-2 transmissions are increasing exponentially with Ro significantly above 1. Intensive care units are at risk of becoming overwhelmed, high and increasing numbers of deaths, mountain rescue teams ask to avoid mountaineering.

Moderate (6). On the brink of community transmission; 10-49 new SARS-CoV-2 cases per 100,000 inhabitants per week; SARS-CoV-2 test positivity 1-5% of SARS-CoV-2; SARS-CoV-2 transmissions are increasing steadily but not exponentially.

Low to negligible (2). No SARS-CoV-2 infections in region or only localized, well traceable outbreaks of <20 people. Generally <10 new SARS-CoV-2 cases per 100,000 inhabitants per week, <1% SARS-CoV-2 positivity of suspected cases. Cases low and/or going down. Few COVID-19 patients in hospital (e.g. <10 per million population) or specifically in intensive care unit (<1 per million population).

B How high is the individual risk of a SARS-CoV-2 infection?

High (10). Lives in city ≥100,000 people, frequent close contact to others (e.g. public transport, work, restaurants), poor adherence to COVID-19 mitigation measures by individual and/or persons with close contact (face masks, social distancing, hand washing), international travel to high risk areas or high risk activities (e.g. weddings, house parties) within the last 14 days.

Moderate (6). Lives in city <100,000 people, occasional close contact to others, mostly compliance with COVID-19 mitigation measures, no or few risk situations within the last 14 days.

Low to negligible (2). Lives in a village, works from home, rare contact with others, high adherence to COVID-19 mitigation measures, no risk situations within the last 14 days

C How likely is it that a mountaineer suffers a severe course of COVID-19 or dies, if she/he should become infected with SARS-CoV-2?

High (10). ≥70 years old, unfit and/or obese and/or poorly controlled/major diseases (e.g. myocardial infarctions, poorly controlled type 2 diabetes mellitus or hypertension, immune suppression).

Moderate (6). Between 50 and 70 years old, moderately fit and/or slightly overweight and/or mild chronic disease (e.g. controlled hypertension or type 2 diabetes mellitus).

Low to negligible (2). <50 years old, fit, normal weight, no known chronic disease.

D How high is the SARS-CoV-2 infection risk during the planned mountain sport and during associated activities?

High (10) Most likely, no outdoor mountain sport of itself is high risk for SARS-CoV-2 infection but when there is an overall moderate to high risk of infection based on the above criteria, then the risk can be high in mountain sport-associated situations such as travel to high risk areas, public transport in full buses or trains, repeated stays in busy mountain huts, poor adherence to COVID-19 mitigation measures.

Moderate (6) Overall moderate risk of a SARS-CoV-2 infection. Mountain sports that require close contact with 1-2 other persons (e.g. bouldering, climbing), travel on public transport, stays in mountain huts with COVID-19 mitigation measures in place (e.g. ventilation, face masks).

Low to negligible (2) Overall no community transmission and low numbers of cases. Solo mountain sport or mountain sports with few others with social distancing (e.g. hill walking). Day trips, individual travel.

Add the scores for all answers and calculate an overall risk score. Additionally, check whether you agree with the overall risk rating. If in doubt, assume the higher overall risk category.

Overall risk score: 8-12 points: A SARS-CoV-2 infection during the planned mountaineering activity is highly unlikely (e.g. a hypothetical risk of a COVID-19 infection of <1 in 10,000 during mountain sports activities). Moreover, should a mountaineer become infected nonetheless, then the risk of a severe course of SARS-CoV-2 or death is low and the health system can easily cope. **Recommendation**: COVID-19 mitigation measures are unnecessary but common sense measures such as avoiding handshakes, maintaining a degree of social distancing and avoiding putting climbing gear in the mouth should be continued as part of the new normal.

Overall risk score: 13-24 points: Overall moderate risk. A SARS-CoV-2 infection during mountain sport or during mountain sport-associated activity exists (e.g. a hypothetical risk of becoming SARS-CoV-2 infected of up to 1 in 1000 during mountain sports activities). If it occurs, then the risk of severe COVID-19 or death is below 1% and the health system can still cope. **Recommendation**: Mitigate the risk of a SARS-CoV-2 infection mountain sports and reduce the risk of a SARS-CoV-2 infection during associated activities (e.g. individual travel instead of public transport, no stays in bunkbeds with other parties, preferably day trips only). Support contact tracing by taking addresses and telephone numbers of other members in the party.

Overall risk score: 25-40 points: Overall high risk: Essentially it is a high risk individual in a high risk situation. More specificially, this means that the risk of a SARS-CoV-2 infection is high and if a mountaineer becomes infected then this would mean more work for a health system at the brink and the risk of serious COVID-19 disease or death is considerable for the mountaineer. Most governments will impose curfews/lockdowns that may or may not affect mountain sports when community transmission is increasing in a controlled manner. **Recommendation**: Consider avoiding mountain sports. If mountain sports are still permitted and seem justifiable, maximally reduce the risk of a SARS-CoV-2 infection by rigorously adopting COVID-19 mitigation measures during mountain sports and in associated situations (e.g. only individual travel, only day trips, avoid mountain uplift, do not stay with others in

accommodation). Also greatly reduce the risk of accidents (only good weather, avalanche risk minimal, climbs well within ability). Support contact tracing by taking addresses and telephone numbers of other members in the party. Gentle hill walking, either solo or within household, extended household or 'support bubble' groups, will always be the safest activity.

Quality of the evidence. Score-based risk assessment tools allow to condense risks and risk factors to a few categories such as "high risk", "moderate risk" or "low to negligible risk". In the context of SARS-CoV-2, the WHO has developed such as risk assessment tool for sports events (WHO, 2020c). The limitation is that the risk assessment and scoring scheme is subjective.

Question 2

Droplet and aerosol mitigation measures: How can the risk of droplet and aerosol SARS-CoV-2 infections be reduced during a belay changeover, when sharing a gondola or other situations where social distancing is not possible?

Background. Generally contacts of less than 2 m can be easily avoided during mountain sports such as hill walking but not during several other disciplines of these sports. Examples for the latter are spotting during bouldering or when sharing a belay on a multi-pitch climb. In these situations, SARS-CoV-2-infected, asymptomatic mountaineers can potentially infect others via respiratory droplets. However, despite that, outdoor infections (Qian et al., 2020; Swinkels, 2020) and infections during actual mountain sports (see above) are rare. Moreover, airborne (i.e. aerosol-mediated) infections can occur in mountain sports-associated situations such as gondolas, tents, mountain huts or when travelling to or from a mountain sport venue together with other people.

Answer. If the overall risk is rated "moderate" to "high" then the risk of droplet or aerosol SARS-CoV-2 infections should be mitigated as follows (the higher the risk, the stricter should the mitigation measures be):

- **Social distancing**: Generally, social distancing of >1.5 or 2 m is the norm and easy e.g. during a hill walk but this may not be feasible on a stance on a multi-pitch climb. Alternatively, if the overall risk of a SARS-CoV-2 infection is moderate but if the individual risk of a SARS-CoV-2 infection and of its consequences is low (before and after the activity), then a pair of boulderers or climbers may consider travelling and climbing without mitigation whilst avoiding mountain sport-associated risks. One way of reducing the risk during shared travel in a private car is to limit occupancy to 2, have both seated in the front wearing masks, have the fan system running and directed so the air flow passes the head, and the rear windows partially open to allow exit of air.
- **Face masks**: If the risk is moderate and if social distancing is difficult or impossible, wear face masks, especially indoors or if in close proximity with others for more than 15 minutes. If the risk is high, avoid situations where social distancing is impossible.
- **Talking**: As droplets and aerosols are more abundantly produced when talking loudly (Asadi et al., 2019), mountaineers should speak more quietly when not being able to keep a >1.5 or 2 m distance. They should also avoid face-to-face situations.
- **Indoor situations**: Gondolas or mountain huts should be well ventilated to avoid high concentrations of potentially SARS-CoV-2-contaminated aerosols (Buonanno et al., 2020). If the overall risk is high, avoid indoor situations associated with mountain sport completely.
- **Contact tracing**: If close contact occurs by accident or is unavoidable, note phone numbers and e-mail addresses to support swift contact tracing in case a mountaineer subsequently tests positive (Breeher et al., 2020).

Quality of the evidence. For ethical and hygiene reasons, there are no direct studies that investigate how droplets from a SARS-CoV-2-infected individual are transmitted to another individual. However, there is good evidence that droplets and aerosols are generated during coughing, sneezing (Bourouiba et al., 2014), talking (Asadi et al., 2019) and that SARS-CoV-2 can remain active for hours in experimentally generated aerosols (van Doremalen et al., 2020). Thus infections via droplets or aerosols are highly likely. Moreover the fact that many

superspreader events where 5 or more people become SARS-CoV-2 infected occur mainly indoors (Qian et al., 2020; Swinkels, 2020) suggests that this is also true for indoor situations associated with mountain sports such as gondolas or mountain huts.

Question 3:

Fomite mitigation measures: How can SARS-CoV-2 the risk of infections via SARS-CoV-2-contaminated surfaces be reduced during bouldering, climbing or on via ferrata, where the same surfaces are touched by several people?

Background. Boulderers, climbers and via ferrata goers touch rock, ropes, quick draws and other jointly used equipment. Thus SARS-CoV-2-infected subjects may touch their mouth or nose, collect SARS-CoV-2-contaminated mucus or saliva and may then deposit this on rocks, ropes, steel cables or other gear. Other boulderers, climbers or via ferrata goers may then touch these surfaces, collect SARS-CoV-2 and may trigger infections if they touch their nose or mouth. How likely is such a scenario and how can it be avoided? The virus can remain viable on surfaces for days (van Doremalen et al., 2020) but outdoors, mucous or saliva deposits may dry quickly which will inactivate SARS-CoV-2 while sunlight will destroy the virus within minutes (Schuit et al., 2020). Moreover, experiments that assess the time frame of SARS-CoV-2 viability on surfaces in a laboratory experiment may use conditions that do not resemble outdoor conditions (Goldman, 2020).

Answer. The risk of infection from contaminated surfaces during mountain sports can be mitigated as follows:

- **Hand disinfection and hygiene**: The most important mitigation method against surface SARS-CoV-2 infections is good hygiene, hand washing and the use of hand sanitisers. The last of these is practicable during some mountain sports, especially during single pitch climbing and bouldering. The use of liquid chalk (≥70% alcohol) will disinfect hands, so may be an option.

- **Avoid touching the face**: Not touching the face and especially the mucous membranes of the mouth and nose will reduce the risk of an individual infecting themselves after contact with a contaminated item. During climbing, climbers sometimes place equipment in their mouths and this should be avoided.
- **Disinfection of surfaces and equipment**: Disinfection of ropes, slings, harnesses and similar items of equipment is impractical because of manufacturers' restrictions on treatments that will compromise the performance of the equipment. However, washing all equipment in a large volume of warm water, then rinsing and drying thoroughly after use, will dilute any deposited virus several million-fold.

Quality of the evidence. As yet, there are no published studies that have investigated the viability of SARS-CoV-2 on climbing holds or surfaces associated with mountain sports. As a result, we do not know whether the risk of infection from SARS-CoV-2 contaminated surfaces during climbing is negligible or a real threat. Experimental studies suggest that SARS-CoV-2 and similar viruses can remain viable on surfaces for up to 9 days under laboratory conditions (Kampf et al., 2020; van Doremalen et al., 2020), but it is not known how this compares to . when SARS-CoV-2 deposits might dry quickly and be exposed to UV light (Goldman, 2020), which increases with altitude (Okada et al., 2013; Schmucki and Philipona, 2002).

Question 4:

When can mountaineers return to mountain sport after a positive SARS-CoV-2 test or COVID-19 diagnosis?

Background. Some mountaineers may become infected with SARS-CoV-2 during mountain sports or elsewhere. When can they return to sports and specifically mountain sports? Here, the German Society for Sports Medicine and Prevention, and the Medical Commission of DOSB have developed a recommended procedure (Nieß et al., 2020). Note that this is based on data at the time of writing and as e.g. information about "long COVID" emerges (Mahase, 2020), recommendations may change e.g. for those who continue to suffer from symptoms.

Recommendation. We recommend to follow the flow chart that is the central part of the recommendations (Nieß et al., 2020) to mountaineers who become infected with SARS-CoV-2. It is illustrated in **Figure 3**.

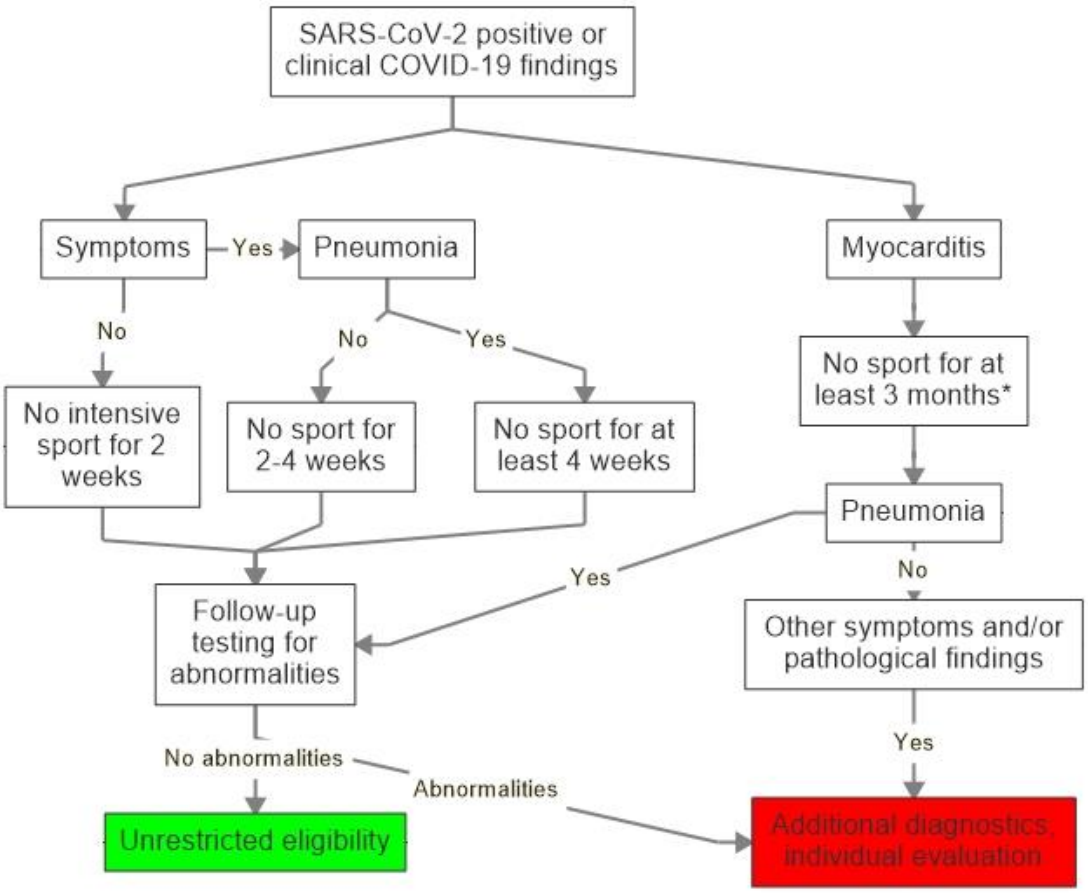

Figure 3. Simplified flow chart detailing the return to sport recommendations for athletes that became infected with SARS-CoV-2 modified after German recommendations (Nieß et al., 2020). *Follow guidelines for myocarditis as indicated in Nieß et al (2020).

Quality of the evidence. The flow chart illustrated in **Figure 3** is based on expert medical opinion and there is no scientific evaluation whether the recommendations are excessive or unsafe. Such an approach is pragmatic and justified because clinicians need guidance on what to recommend to athletes and mountaineers after a SARS-CoV-2 infection. However, the flow chart should be modified once robust scientific evidence emerges that suggests alternative recommendations.

5) How should mountaineers plan and carry out remote and/or high altitude expeditions?

Background. Regional pathogens or food poisoning can cause infections during mountaineering expeditions (Ericsson et al., 2001). However, at what infection level should mountaineers consider high altitude and other mountaineering expeditions and what are suitable precautions?

Answer.

- We recommend that mountaineers only embark on mountaineering expeditions if the risk of a SARS-CoV-2 infection is rated as low or negligible. Expedition members should also ensure that a planned expedition is not against the wishes of the communities that live in the region where the expedition will take place.
- Symptoms such as shortness of breath, headaches and dry cough are common to a stay at high altitude and are also symptoms of COVID-19. Should such symptoms develop even though the risk of a SARS-CoV-2 infection was rated low to negligible, then the team should practice social distancing, isolate the affected individual(s) and check for COVID-19-specific measures such as fever or a loss of smell and taste (Nunan et al., 2020). Should such symptoms be present, the expedition should not proceed until it is verified that there is no COVID-19 infection.

Quality of the evidence. There are no studies that have investigated SARS-CoV-2 infection risks during expeditions and there are no reports of SARS-CoV-2 infections during expeditions, so these recommendations are subjective.

Summary and conclusions. Given that outdoor SARS-CoV-2 infections are rare (Qian et al., 2020; Swinkels, 2020) and given that there are very few reports about suspected SARS-CoV-2 infections during mountain sports, we should assume for now that the risk of a SARS-CoV-2 infection during actual outdoor mountain sport is low. In contrast, there are indoor mountain

sports-associated activities such as busy public transport to mountain areas, stays in mountain huts, and mountain uplift where there are known risks for SARS-CoV-2 infections. Thus, if the overall risk is moderate to high, governments, mountain sports associations and mountaineers should seek to control mainly the risks of mountain sports-associated activities whilst not limiting safe activities such as hill walks. The fact that it is possible to resume league football and to organize the Tour de France with only isolated examples of limited outbreaks of SARS-CoV-2 infection among the participants suggests that mitigations measures such as bubble concepts work and can make especially outdoor sports sufficiently safe even when the SARS-CoV-2 infection risk is moderate to high.

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