SARS-CoV-2 safer infection sites: moral entitlement, pragmatic harm reduction strategy or ethical outrage?

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ABSTRACT

The pandemic of SARS-CoV-2 has led to unprecedented changes to society, causing unique problems that call for extraordinary solutions. We consider one such extraordinary proposal: 'safer infection sites' that would offer individuals the opportunity to be intentionally infected with SARS-CoV-2, isolate, and receive medical care until they are no longer infectious. Safer infection could have value for various groups of workers and students. Health professionals place themselves at risk of infection daily and extend this risk to their family members and community. Similarly, other essential workers who face workplace exposure must continue their work, even if have high-risk household members and live in fear of infecting. When schools are kept closed because of the fear that they will be sites of significant transmission, children and their families are harmed in multiple ways and college students who are living on campus, whether or not they are attending classes in person, are contributing to high rates of transmission and experiencing high rates of exposure. We consider whether offering safer infection sites to these groups could be ethically defensible and identify the empirical unknowns that would need to resolve before reaching definitive conclusions. This article is not an endorsement of intentional infection with the coronavirus, but rather is meant to spark conversation on the ethics of out-of-the-box proposals. Perhaps most meaningfully, our paper explores the value of control and peace of mind for those among us most impacted by the pandemic: those essential workers risking the most to keep us safe.

INTRODUCTION

In response to the COVID-19 pandemic, extraordinary measures that would not normally be considered have been proposed. One example, proposed early in the pandemic, is immunity passports, or documents verifying an individual's immunity to the novel coronavirus (based on antibody testing) and conveying increased rights, such as travel or return to work, for the individual with immunity.[1] Another example is mandatory service in a health corps or a compulsory draft for young individuals to be trained as first responders and essential workers to provide aid during the pandemic.[2]

This paper considers another such extraordinary measure: allow certain groups of people to choose to be intentionally infected with SARS-CoV-2 and to isolate and receive medical care in designated facilities ('safer infection sites'), where their risk of infecting others is minimised. Those who use safer infection sites will know the time and place of their infection, thus reducing their risk of asymptomatically transmitting SARS-CoV-2 to other people. For example, a doctor on the front-lines of the COVID-19 response, worried about unwittingly bringing the virus home and infecting their loved ones, could avoid this outcome by using a safer infection site. This option might be particularly valuable to those who live with people at high risk of severe COVID-19 illness.

As we will argue, we think that the most defensible use of safer infection is by healthcare workers. However, use of safer infection by other groups may also be defensible, such as other essential workers who are at higher risk of SARS-CoV-2 infection, especially if they have inadequate protections in the workplace, do not have access to SARS-CoV-2 testing or live with people at high risk of severe COVID-19 illness. Also, given the high prevalence of 'at-risk' behaviours exhibited on many campuses so far during the Fall 2020 semester, use of safer infection by college students may also have value. Another population at significant risk of asymptomatic transmission is children attending day care and school. Given the significant harms associated with school closure and children's low risk of severe COVID-19 illness, children could be deemed a high priority population for intentional infection. One might even consider making safer infection sites available to people in general, following the logic of harm reduction. People are going to frequent bars, have parties and engage in other forms of social activity that pose a risk of virus transmission and even 'super spreader events'. In addition, there is anecdotal (though admittedly unverified) evidence that some people are intentionally trying to infect themselves with SARS–CoV-2.[3] Perhaps we should accept the inevitability of this risky behaviour and at least try to make it safer, by offering people safer infection.

Whether it would be defensible to offer safer infection to a given group depends on a number of ethical considerations, among them: what benefits does safer infection offer to that group and are there better ways of achieving those benefits? Safer infection would not be defensible for a group that has ready access to less risky ways of preventing infection and/or transmission, such as adequate workplace protections, a safe and effective vaccine (which has been shown to prevent infection and transmission, not just to reduce severity of disease) or highly accurate rapid testing.

This paper sketches out the general case for safer infection sites, using the USA as a case study and considers their use by healthcare workers, healthy children, college students and the general

population. We consider ethical arguments for and objections to safer infection sites. It is worth emphasising at the outset that there are key empirical unknowns that must be resolved before advocating for safer infection sites—in particular, whether infection with SARS-CoV-2 provides lasting immunity to reinfection and how long people are infectious after being infected with SARS-CoV-2. Given these unknowns, the aim of this paper is not to advocate for safer infection sites but rather to consider 'in principle' arguments for them.

Safer infection sites

A safer infection site would be a facility where people are knowingly and voluntarily exposed to a specific dose of SARS-CoV-2. These sites would provide appropriate monitoring, medical care and testing of the individual until they have recovered from the illness and would expect them to remain at the site until they no longer pose a risk of infecting others. Such facilities could be state funded and staffed or could be run by private entitles with oversight by public health authorities. For example, a national health service could run safer infection sites. Or a university, after approval from a local health department, could designate a dorm to be a safer infection site, hire healthcare workers to staff it and fund the whole operation themselves.

The value of safer infection

Safer infection sites would allow users to control their time of infection and remain safely isolated until they are no longer infectious, thereby preventing their asymptomatic and presymptomatic transmission of SARS-CoV-2. Early data from the United States Centers of Disease Control and Prevention (CDC) estimated that at least 1/3 of COVID-19 cases are asymptomatic and result in 40% of the total viral transmission. Recent studies now show that at least three quarters of transmission occurs in the early days of infection, with almost half occurring when individuals are still asymptomatic.[4] Although some proportion of these individuals may go on to develop symptoms, live coronavirus sheds at high concentrations from the nasal cavity even before symptom development.[5] Thus, without equivocation, asymptomatic and presymptomatic transmission of SARS-CoV-2 is a significant source of infection.

It could have significant value to individual workers or students to be assured that they will not asymptomatically or presymptomatically infect others: they would not infect the people they live with, or have to take disruptive measures to prevent such infection or live in fear of infecting them. It could also have significant value to individuals to be immune and to know that they are immune: this could reduce the time they spend in quarantine, and thus reduce lost days of school, lost days of work and lost wages. Having confidence in their immunity could also enable people to engage in a wider range of social activities that they would otherwise avoid, for example, visiting sick or elderly relatives or attending worship services.

Safer infection could also have value for institutions. For example, as we discuss below, if colleges offered safer infection to returning students, those students could engage in a more normal college experience and avoid carrying infection back home with them. It is conceivable–though speculative—that offering safer infection could be an incentive for students to return to campus, thus enabling universities to avoid financial losses. Other institutions might benefit from staged safer infection, in which small groups of workers are successively safely infected, helping the institution avoid the bad outcome in which the virus hits the workplace and infects many coworkers at once, undermining the institution's performance. The current White House administration narrowly avoided this scenario when President Trump contracted the virus after attending a largely mask-free event in the Rose Garden in late September.[6] The nation's top infectious disease expert, Dr. Anthony Fauci, recognised this incident as a superspreader event, one in which the virus circulated within a wide orbit of President Trump's contacts. Many of Trump's high-level military, national security advisors and legislative members of the Republican Party (also known as the GOP) were exposed and placed in quarantine.

Along with individual and institutional benefits, it is conceivable that there could be public health benefits from safer infection on a wide scale. Robin Hanson considers the possible benefits of controlled exposure, in which groups of people would be deliberately and successively exposed to SARS-CoV-2. He presents modelling results showing that, under certain assumptions about COVID-19 (which may or may not be accurate), a strategy of intentionally exposing young people while quarantining old people reduces deaths by 40%.[7] In this paper, we do not consider, nor do we endorse, mass use of intentional infection as a disease control strategy. Another respect in which safer infection sites could have public health value is that they offer a readymade population in which to conduct 'natural history' studies. Data could be collected on a daily basis of how the disease manifests in different people, how it evolves over time and individual characteristics that are associated with different manifestations of disease. Thus, even if the primary argument for safer infection site would be the benefits they offer to individuals, an ancillary benefit is the social value of research that could be conducted.

Empirical unknowns

For safer infection to offer these benefits, we must be able to have confidence that someone who was 'safely infected' is no longer able to transmit the virus. Thus, we must be able to ascertain how long a person is infectious for (so that we can isolate infected people for long enough), and we must be confident that SARS-CoV-2 infection confers subsequent immunity for some meaningful period of time, which is yet to be determined.

A positive PCR test can confirm infection with SARS-CoV-2 after an initial exposure event. Studies show that viral particles can be shed long after initial infection, but at what point do individuals stop being infectious? No available test actually determines infectiousness.[8] According to the guidance from the US Centers for Disease Control and Prevention, individuals recovered from COVID-19 can resume activity around others if the following parameters have been met: it has been at least 10 days since symptoms first appeared and at least 24 hours with no fever and other symptoms of COVID-19 are improving.[9] The CDC also has guidelines for clearing asymptomatic infections based on the timeline of the individual's known exposure. Thus, perhaps we could have confidence in our ability to determine how long individuals must be kept at safer infection sites to make sure they are not infectious on release.

Recent studies are revealing that nearly everyone who recovers from COVID-19 makes antibodies against the virus within weeks of developing first symptoms. These antibodies last at least 4 months without decline.[10] Researchers are still determining how protective these antibodies are and for how long they last after the initial convalescent period. Studies of SARS-CoV, a genetically similar virus responsible for severe acute respiratory syndrome, may help inform this discussion. Antibody testing for SARS-CoV, for instance, shows that immunity for this virus peaks at 4 months and offers protection for 2–3 years.[11] Thus, it may turn out that SARS-CoV-2 infection provides immunity for 2–3 years; however, safer infection sites would only make sense once

there is additional evidence of immunity and more clarity about the duration of immunity. For the sake of argument, we assume that there is evidence that infection provides lasting immunity of known duration (eg, several months) and considers the case for safer infection given that assumption.

The ethics of safer infection

Would it be ethically defensible for the state, or a private institution, to offer safer infection sites? If so, who should be eligible? Answering these bottom-line ethical questions requires getting clear about the benefits safer infection offers to different populations as well as its risks. In the following sections, we discuss distinct groups of candidates for safer infection, the ways in which they or others might benefit from their use of safer infection and the medical risks associated with their use of safer infection (as best we know). But before considering the fine-grained ethical case for safer infection, group by group, three general ethical issues will be considered.

First, could the availability of safer infection and transmission result in some groups being coerced into participating? For example, if healthcare workers are offered safer infection, and employers preferentially hired or staffed healthcare workers who had immunity, this would create an incentive for healthcare workers to intentionally infect, even if they preferred not to. Arguably this could be amount to a form of coercion. Similarly, if a college offered safer infection to students and made return to campus contingent on participating (or demonstrating immunity in some other way), this could arguably amount to coercion.

In our view, it would be an ethically unacceptable outcome if workers intentionally infected themselves with SARS-CoV-2 just in order to maintain their wages or employment or college students engaged in safer infection only to be allowed to return to campus. We need safeguards to prevent this, by preventing employers and colleges from favouring the immune in these ways. But it is important to note that we need these safeguards whether or not safer infection sites are implemented. Workplace discrimination against the non-immune will be a concern as more people become immune through naturally acquired infection and wider availability of antibody testing offers more people evidence of immunity.

Second, how would offer safer infection fare from the perspective of justice and equity? Suppose, as discussed in the previous paragraph, some employers made returning to work or working shifts contingent on having immunity, and workers were essentially coerced into intentionally infecting themselves. Those who are most vulnerable economically–those who cannot afford lost wages, who most need overtime pay or who are least able to find a different job—would have the greatest incentive to intentionally infect themselves, would be most subject to coercion. This is an unacceptable result, which should be prevented by prohibiting employers from favouring the immune in hiring and staffing.

Third, safer infection might simply strike some as a morally outrageous idea. Rather than using deliberate infection to reduce people's risk of transmitting the virus, should not we redouble our efforts to reduce their risk by protecting them from infection? For example, risk of workplace transmission can be kept very low through use of personal protective equipment (PPE), which, if used appropriately, drastically mitigates the risk of infection during exposure to the virus. We could also make workplace and school environments safer in other ways—for example, by having high-quality air filtration systems and mandating the use of masks. We could reduce infected people's risk of transmitting the virus by developing highly accurate rapid tests and making these widely available—in which case, people could simply isolate once they test positive and would not need to deliberately infect themselves in order to know when they were infectious. More generally, is not a better way of reducing asymptomatic (as well as symptomatic) transmission of the virus to have an effective public health response? For example, a robust 'Test-Trace-Isolate' programme, that uses widespread testing to identify infected people, robust contact tracing to identify their contacts and quarantine of contacts to prevent them from asymptomatically spreading the virus?

Yes, we should have those other measures in place. But these measures have not been in place everywhere throughout the pandemic, including now. Shortages in PPE still exist, and in some products are worsening, in the USA, as supply chain deficiencies have yet to be solved.[12] As a result, hospitals, nursing homes and other medical practices have had to acquire supplies through back channels and expend time decontaminating disposable masks and gloves. Not to mention, these one-time use products, which are now being used until ineffective, increase healthcare workers' risk of disease exposure. As for 'Test-Trace-Isolate', some have questioned whether it is realistic to stand up sufficiently robust contact tracing efforts in all places, for in states in the USA with relatively weaker public health systems.[13] In May, most US states were not on track to have enough testing and contact tracing capacity.[14] Only 17 states have made some amount of staffing and/or transmission data publicly available, suggesting that 33 states continue to lack capacity for adequate contact tracing. While rapid tests are beginning to be deployed, these tests remain unavailable to many Americans, especially those who are asymptomatic.[15]

In addition, even if protective measures are available, people may not follow them assiduously enough to minimise risks of infection and transmission. For example, an essential worker might have coworkers who do not reliably use PPE, would not get tested regularly and would not self-quarantine if exposed to a SARS-CoV-2-positive person. Offering this essential worker access to safer infection allows them to protect their families from infection even if coworkers are not willing to follow the rules.

It is also worth considering how a robust public health response might affect workers and students. Currently, there remains a significant rate of SARS-CoV-2 infection in some areas, with the US case number nearing 7 million. If infection is already widespread in an area, a robust testing and contact tracing effort would investigate a large number of cases and identify a large number of contacts, who are asked to quarantine at home for 10–14 days. Many contacts will not actually be infected with SARS-CoV-2, and they might subsequently be exposed again and asked to quarantine again. Thus, some individuals could be asked to quarantine repeatedly, especially those whose work involves a higher risk of exposure. As more children return to school and the weather gets colder (which is likely to increase transmission), more cases may be discovered in schools and more schoolchildren asked to quarantine at home from school for 10–14 days. This repeated quarantine would be extremely burdensome. Will workers receive paid leave from work each time, if they are not legally entitled to it? When exposed individuals do turn out to be infected, how will they reliably avoid infecting the people they live with while they isolate at home? As COVID-19 cases continue to spread across the USA at a variable rate, it has been possible to conceive of a scenario where robust implementation of a 'Test-Trace-Isolate' containment strategy could be financially and practically burdensome on essential workers. Safer infection sites offer another alternative to those people who have a high

occupational or social risk of SARS-CoV-2 exposure. They could intentionally infect themselves, isolate away from their households while they recover and subsequently avoid transmitting the virus to others, potentially having to quarantine repeatedly and potentially losing wages.

Safer infection sites for frontline healthcare workers

During this pandemic, frontline healthcare workers are diagnosing and treating patients with SARS-CoV-2 and COVID-19, sometimes without proper PPE, including N-95 face masks or Powered Air Purifying Respirators(PAPRs). Although data surrounding healthcare worker infection rates are opaque, evidence suggests that rates can be as high as 3%–20% of reported COVID-19 cases in the USA,[16 17] while early reports from China and the Netherlands cite a 1% infection rate among healthcare workers.[18 19]

Many healthcare workers are not only anxious that they will contract the virus but also that they will then infect others, especially in light of the high rate of asymptomatic transmission of SARS-CoV-2. Healthcare workers may become vectors of infection, posing risks to their families, their coworkers, patients and the community at large.

Household transmission is a major source of SARS-CoV-2 infection, with the secondary rate of transmission among household contacts as high as 30%.[20] Thus, a primary concern of healthcare workers is bringing home the virus and infecting their loved ones. For example, a blog post published by the American Medical Association discusses this fear and how '(using PPE and following proper hand hygiene) are the things that you can do to not get sick and not bring anything home to your family'.[21] Healthcare workers have also intentionally separated from their families, moving into their garage or into a hotel, because they 'do not want to put (their family) at risk or, God forbid, get them sick'.[22] One healthcare worker lived in a pop-up truck camper in the hospital parking lot to avoid infecting her family.[23] This is a particular concern for healthcare workers who live with high-risk people, for example, people who live with pregnant partners or older parents. In the words of one nurse, 'There is a tremendous amount of fear and guilt that we could bring this home and hurt people that we love…We have had colleagues who lived with elderly parents, who unfortunately have gotten sick and have had their parents get sick and passed'.[24]

Safer infection sites would allow healthcare workers to avoid unwittingly transmitting the virus to their household members, to coworkers or to patients. This might be especially important for some healthcare workers, such as those who work in skilled nursing facilities, which have been hard-hit by severe COVID-19 illness and are a major source of COVID-19 mortality. Reports suggest that up to 1/3 of all virus-associated deaths are nursing home residents or workers.[25]

Is it ethical to offer safer infection to healthcare workers? Or does intentional infection with SARS-CoV-2 simply pose too high a risk to healthcare workers, and thus it would be indefensible to encourage healthcare workers to take this risk by giving them access to safer infection sites?

A key empirical issue is how much additional medical risk safer infection entails, over and above healthcare workers' baseline risk. It is difficult to estimate a healthcare worker's cumulative risk of acquiring SARS-CoV-2 over the course of the pandemic. Recent CDC data estimated over 160 000 healthcare workers have been infected in the USA, with 710 dying of the virus.[26] Notably, healthcare personnel status was only available for 24% of the total cases, indicating that this number could be up to 80% higher. From other sparse evidence, there was a 1% infection rate (over the period 1 January to 9 February) among healthcare workers in a hospital in Wuhan, China; early data from the Netherlands supported this 1% infection rate.[18 19] Frontline healthcare workers in some settings will be exposed to and caring for patients with SARS-CoV-2 for a year or 2. Over this period, their cumulative risk of infection will depend on many factors, including the percentage of patients with SARS-CoV-2, the availability of PPE and other protocols in their clinical settings. However, it is reasonable to assume that the cumulative risk of infection will not approach 100%; thus, use of a safer infection site increases the risk of SARS-CoV-2 infection.

An intriguing possibility—though one that is purely speculative at this point—is that safer infection—intentional exposure to a specific dose of SARS-CoV-2—could result in reduced risk of severe COVID-19 illness and death. Some frontline healthcare workers are repeatedly exposed to patients with the virus, and as such, are at risk of getting a higher dose of the virus, which may lead to more severe illness. This cycle of worse disease related to high dose is termed the inoculum effect.[27] If healthcare workers could be intentionally exposed to a lower dose of the virus, this would reduce the likelihood of severe COVID-19 illness.

At this point, we cannot know if intentional infection could indeed be less risky for some healthcare workers than the status quo. Thus, though it is not impossible to quantify given existing data, we should assume that the medical risk to healthcare workers from safer infection significantly exceeds their risk in the status quo.

Is the risk associated with intentional infection with SARS-CoV-2 an acceptable level of medical risk for individuals to voluntarily undertake? This question is under discussion by bioethicists and researchers considering controlled human infection studies of SARS-CoV-2, in which volunteers would be intentionally infected with the virus as part of controlled studies of experimental vaccines and treatments. Expert opinion is mixed about whether the value of that research justifies the medical risks to healthy volunteers.[28 29] But at least some bioethicists consider it justifiable to intentionally infect young, healthy volunteers with SARS-CoV-2 as part of valuable research, so long as the medical risks are minimised by offering them medical care and isolating them for 14 days.[28 29]

The intentional infection of young, healthy healthcare workers at their request differs in two important respects from the infection of young, healthy volunteers as part of medical research. First, many healthcare workers face a higher risk of infection at baseline than the average person; thus, as compared with study volunteers, they are undertaking less additional risk by being intentionally infected. Second, in the scenario we imagine, healthcare workers intentionally infect not because this provides social value, but because it reduces risk to their loved ones, avoids disruption to their home life, afford them peace of mind or has other benefits for them personally. Thus, the ethical issue is not whether it is ethically acceptable to encourage volunteers to altruistically undertake risk as part of a socially valuable research endeavour, but whether it is ethically acceptable to enable healthcare workers to undertake risk in order to benefit themselves and their loved ones. They are risking their health to do essential work, and many are under severe emotional and psychological strain. If safer infection provides them with greater peace of mind, reduces the disruption to their home lives, poses a level of medical risk deemed acceptable in other contexts, and healthcare workers make use of safer infection only after giving informed, voluntary consent, then there is a prima facie case that offering safer infection is ethically defensible.

A further question is whether we owe the option of safe self-infection to healthcare workers—that is, whether the state or private healthcare organisations (eg, a hospital) has an ethical obligation to establish safer infection sites for healthcare workers. In our view, given the risk and expense involved, there is not a compelling case that healthcare workers are entitled to safer infection: neither their employers, nor the state, is obligated to offer them safer infection.

Safer infection for healthy children

Another population that we might consider for safer infection is healthy children: they are at low risk of severe illness but may spread SARS-CoV-2 in daycare and school settings in the absence of widespread immunity. Up to a third of children who test positive are asymptomatic carriers of COVID-19,[30] making schools potential sites of asymptomatic transmission. In France, where schools were temporarily opened to a million students, a sharp increase in COVID-19 cases was seen after just a week, leading the country to close schools again.[31] On the other hand, early evidence suggested that children are less likely to transmit than adults and are not the 'super-spreaders' of the coronavirus as they are for the seasonal influenza.[32] For example, in New South Wales, they have kept schools open and across 10 schools with 12 cases, they found that only 1 in 695 was infected from these cases.[33] Despite this preliminary evidence, a more comprehensive study of OVID-19 paediatric patients conducted by the Massachusetts General Hospital provided critical data showing that children most likely play a larger role in the community spread of SARS-CoV-2 than previously thought. Their finding from nasopharyngeal swabs demonstrated that children can carry a high viral load, making them more contagious to others, regardless of their susceptibility to developing signs and symptoms of infection.[34]

Even if available data suggest that in-school transmission is rare given proper precautions, schools are nonetheless remaining closed in some places because of the risk of transmission or the inability of schools to put proper precautions in place. (This is true in the USA as we write this in October 2020.) These school closures have negative effects on children, their families and the economy.[35] Children are missing significant educational opportunities that could potentially impact the rest of their lives, by impacting their cognitive development, social development and later earning potential.[36] Children, especially those living in poverty, are missing out on food, healthcare and other key services provided by schools. Schools provide children with physical protection against harm; with schools that serve as important abuse reporting centres closed, there has been a 50% decrease in calls to a statewide hotline for suspected abuse. The economy cannot reopen broadly with the workforce at home caring for their children.[35] Opening schools sooner rather than later will have widespread, multifaceted and significant benefits.

Would it make sense to intentionally infect children with SARS-CoV-2 before they return to school, thereby decreasing the risk that close contact in schools leads to transmission of the virus? This might alleviate fears that opening schools would propel community transmission of SARS-CoV-2. Thus, widespread safer infection of children could conceivably facilitate the safer, sooner reopening of schools. Would this be ethically defensible?

Healthy children are at low risk of severe COVID-19 illness and mortality. Initial studies from China suggested that only 1.3% of infections are in children, though according to recent data from the USA, children make up 10% of cases in the USA.[37 38] Children remain unlikely to have severe illness—one study indicates only 6% have severe illness compared with up to 18.5% in adults.[39] Data indicate that children made up only 0.5%–3.7% of all hospitalisations and between 0.2%–8% of paediatric cases were hospitalised.[40] Regarding those hospitalised, recent numbers suggest up to 33% of hospitalised children require care in an Intensive Care Unit (ICU),[40] a rate similar to adult ICU admissions. Investigation into the children who are requiring ICU-level care revealed that 83% had underlying medical conditions. Chronic medical conditions among children are different from those among adults (eg, hypertension, diabetes, chronic kidney disease) and instead commonly involve developmental delay, inherited or genetic abnormalities and/or dependence on life-support technologies such as tracheostomy.[41]

However, this risk, though small, is still orders of magnitude higher than the risks associated with vaccination of children, our standard means of ensuring widespread immunity to disease. Surveillance of vaccine-related adverse events has borne out vaccines' safety, though adverse outcomes in children do rarely occur. The risk of anaphylaxis, or a sudden, potentially life-threatening, allergic reaction, does exist, although it is extremely rare in all age groups. One study found that the rate of anaphylaxis to be 1.31 (95% CI 0.90 to 1.84) per million vaccine doses or 0.000131%. While an estimated 2% ICU admission rate of known paediatric infections with SARS-CoV-2 may seem relatively insignificant, incidence of anaphylaxis after vaccine injection is less than 1/10 000 of the rate of ICU admission for children with SARS-CoV-2, for example.[40]

In addition, our understanding of the COVID-related risks to children is still evolving. Beginning in May of 2020, there was an increasing number of cases of a disorder connected to SARS-CoV-2 infection, Multisystem Inflammatory Syndrome in Children (MIS-C). This autoimmune-like illness causes capillary leak, end-organ dysfunction and potential long-term cardiac, endovascular and pulmonary damage and even death.[40] So far in the USA, there have been almost 1000 documented cases of MIS-C with 19 deaths.[42] Research on genetic susceptibility to COVID-19 might reveal a mutation that is associated with an increased risk of developing MIS-C.[43] In that case, children can be genotyped prior to admission to a safer infection site and only those at low risk of developing MIS-C would be eligible.

Another obstacle to mass intentional infection of children is how and where their isolation would occur. If children were expected to isolate at safer infection sites for weeks, away from their families, this may be harmful to some children. Or perhaps younger children could be accompanied by a parent, who would also be infected. If children instead isolated at home after infection, they might end up being sources of infection for the people they live with and the community, thus, cancelling the benefits of safer infection. The practical challenges to safer infection of children are many.

In sum, it is hard to justify mass intentional infection of children to enable safer and sooner school reopening. However, perhaps a more limited role for safer infection can be envisaged. If schools do reopen in the absence of widespread immunity, students will become vectors of infection into their homes. If students live with people at high risk for severe COVID-19 illness, they or their parents or guardians may be reluctant to send them back to school. However, if they were enabled to intentionally infect and thereby become immune to SARS-CoV-2, they could return to school without posing this risk. Thus, perhaps a case could be made for allowing healthy children who live with high-risk people to make use safer infection sites, at least once the COVID-19 risks to children are better

understood. The same argument could be made about offering safer infection for school workers.

Safer infection sites for college students

It has been a newsworthy start of the Fall 2020 semester for countless colleges and universities across the USA. Many schools have elected to suspend in-person classes after having started with in-person attendance. The virus spread rampantly from one student to the next amidst fraternity parties. Waves of students on college campuses are becoming infected with the virus—inadvertently, apathetically or recklessly. As of September 2020, there have been 88 000 cases linked to college campuses in the USA and at least 60 associated deaths; over 150 campuses have reported at least 100 cases.[44] Colleges have responded by not opening for classes at all, suspending classes for the semester, isolating students who tested positive in 'COVID-19' dorms or quarantining entire groups of people following a known exposure event.[45]

Safer infection could have multiple benefits for college students and their contacts. It could prevent them from infecting others (eg, parents at high risk of severe COVID-19 illness). It would allow them to interact with each other and engage in sports and other extracurricular activities without fear of spreading the virus, which would have mental health and social benefits for them and give them a more typical college experience. If a sufficient number of students on a campus engaged in safer infection, this could reduce the chance of widespread infection, reducing rates of illness among students themselves, faculty, staff and workers who keep the colleges functioning (eg, food service and sanitation workers) as well as local restaurants and businesses. There would be economic benefits for the colleges and local communities if infection rates were low enough to allow colleges to remain open or to 'reopen' at greater capacity.

However, the case for widespread safer infection of college students is highly speculative. It would be problematic for colleges to require students to participate in safer infection sites, and thus it is uncertain whether sufficient numbers of students would participate to achieve significantly lower transmission rates on camps. The financial costs of opening and staffing safer infection could be prohibitive, and it is uncertain whether widespread safer infection would actually be more effective than other measures colleges could take (such as stricter social distancing rules). The question, then, is not whether widespread safer infection is appropriate but whether it would be ethically defensible for colleges to offer safer infection to individual students who wished to participate.

Is the risk associated with safer infection an acceptable level of risk for individual college students to voluntarily undertake? In the absence of mortality or acute complications, negative health effects of the virus on organ systems other than the lungs are beginning to emerge. Myocarditis, or inflammation of the heart, has been seen in healthy patients, though it is rare.[46] Long-term impacts of COVID-19, even in younger patients with mild symptoms, cannot yet be known. Again, at least some bioethicists consider it justifiable to intentionally infect young, healthy volunteers with SARS-CoV-2 as part of human challenge trials, so long as the medical risks are minimised by offering them medical care and isolating them for 14 days.[28 29] If safer infection helps college students avoid infecting their close contacts, allows them to have a more typical college experience and they make use of safer infection only after giving informed, voluntary consent, then there is a prima facie case that offering them safer infection is ethically defensible.

Safer infection as harm reduction

What if safer infection sites were available to anyone who wished to use them? Or, more conservatively, available to anyone in a suitably defined 'low risk for severe COVID-19 illness' category (eg, people under age 40 without underlying health conditions)? Should we offer healthy, young people the option of safer infection, if they are capable of giving informed consent?

Some people may attempt intentional infection whether or not it is sanctioned. There is some indication that people are intentionally infecting themselves with SARS-CoV-2, including inmates at a California correctional facility drinking from the same cup in an effort to infect themselves and rumours in Washington state of people holding 'coronavirus parties'.[3 47] Even if not intentionally infecting themselves, some people are engaging in risky social activity—for example, the college students described in the previous section.

If people are going to attempt intentional infection, or engage in risky social activity, should we get ahead of it and offer them safer infection sites, to reduce the risks they pose to themselves and others? This is essentially adopting a harm-reduction strategy towards intentional infection: accept the reality of a risky behaviour and try to reduce the harms associated with that behaviour.

This style of harm reduction has been advocated by Julia Marcus, an epidemiologist at Harvard Medical School, although on a smaller scale. When she saw park-goers being shamed on social media during the statewide lockdowns, she was reminded of the shaming gay men faced for having sex during the height of the AIDS crisis—an attitude that was both ethically problematic and unproductive. Marcus argues that it is unrealistic for people, who are social beings, to remain shut-in to their house for months on end. The real task, then, is to understand how we can mitigate the risk of contracting the virus as people venture out. Enabling people to meet with friends while wearing masks in a public park, for instance, is better than having them meet indoors, which they might do in response to public shaming.[48]

Here, we have taken this idea of harm reduction to its logical conclusion, in the form of safer infection sites for the coronavirus. We can see this use of safer infection sites as analogous to safe injection sites or supervised consumption sites for illicit drug use: drug use is a risky behaviour of self and others, just as engaging in risky social behaviours during COVID-19 or intentional self-infection are risky behaviours for self and others. In the case of drug use, supervised consumption sites are places where community members can use illicit drugs while having access to clean supplies (eg, clean needles) and the supervision of trained personnel to respond in cases of overdose.[49] Over 100 peer-reviewed studies support the efficacy of supervised consumption sites in decreasing infections, overdose deaths and the corresponding costs of emergency services and hospitalisations. Analogously, perhaps safer infection sites could reduce the harm that individuals pose to themselves or others.

Of course, intentional self-infection with SARS-CoV-2 is disanalogous in one respect to drug use and risky social behaviour: it is not pleasurable nor addictive, nor otherwise valuable in and of itself. Rather, it is an indirect means to an end—whether that be immunity from repeat infection, access to social benefits or decreased anxiety for the individual. Nonetheless, the logic of harm reduction still applies.

Some opponents of harm reduction strategies argue that they increase the rate of harmful behaviours; however, evidence shows a drastic decrease in needle sharing by 38%, decrease in HIV infections by 18.5% (as opposed to increases in cities

without these programmes) and a 50% increase in methadone maintenance programmes resulting in decreased heroin use.[50] Harm reduction strategies are broadly accepted by public health in the context of illicit drug use. However, the logic underlying safe injection sites and clean needle exchanges is that drug use is inevitable—as the thinking goes, individuals with active addiction will use; it is only a matter of how and when. Whether the same logic applies to intentional infection with SARS-CoV-2 is unproven as of yet, as there is only anecdotal evidence of people intentionally infecting themselves. Others against harm reduction strategies often take a more moralistic stance, and the concept of safer infection sites would not be immune from the usual objections. Such opponents would likely call into question the morality of deliberately infecting yourself, elevating the notion that coronavirus infections should be stamped out, not facilitated—whatever that cost may be.

CONCLUSIONS

The SARS-CoV-2 pandemic has necessitated 'out of the box' solutions to the unique problems we are facing. In a world where the threat of infection persists until the advent of a vaccine (likely months away), forward-thinking solutions, even seemingly outrageous ones, must be considered, especially if we are to push our society towards a new normal while also mitigating risks. Akin to harm reduction strategies, we explore what it would look like to provide safer infection sites for various at-need populations. Most importantly, we ask whether these sites could help reduce the spread of unintended infections and protect those most at-risk from contracting severe COVID-19 illness.

There remain many questions concerning the feasibility of such an approach beyond the inherent risk-benefit analysis performed in this article. Not only does the science behind SARS-CoV-2 immunity need to become more robust but we must also consider the economic costs associated with safer infection sites. These include the cost of employing personnel, providing medical supplies, and ensuring sanitation and upkeep. Conceivably, the financial costs of safer infection sites could be outweighed by the financial benefits, if safer infection reduces the number of high-risk individuals hospitalised with severe disease, though this is speculative. Regardless of the eventual efficiencies of safer infection sites, up-front funding would be needed. Potential funding sources could include employers who are offering safer infection to their employees (eg, a large hospital system), higher education institutions who are offering safer infection to students, governments or private philanthropists.

While we do not endorse intentional infection with the coronavirus, as there remains a substantial lack of evidence regarding its short-term safety and long-lasting implications, this article rather serves to stimulate conversation on the ethics of our current public health response and what can be viewed as ethically defensible proposals.

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REFERENCES

1 Phelan AL. COVID-19 immunity passports and vaccination certificates: scientific, equitable, and legal challenges. *Lancet* 2020;395(10237):1595–-1598.
2 Carpenter C. America needs a national service draft now to fight the coronavirus. foreign policy. The Slate group, 2020. Available: https://foreignpolicy.com/2020/04/07/america-needs-national-civilian-service-draft-to-fight-coronavirus/ [Accessed Jun 2020].
3 Denyer LA. 'You can easily kill someone you love': Cooper speaks out against those attending Triad 'COVID-19 parties' [Internet]. *WXII12*, 2020. Available: https://www.wxii12.com/article/winston-salem-north-carolina-hospital-coronavirus-party/32585229/ [Accessed Oct 2020].
4 Ferretti L, Ledda A, Wymant C, *et al*. The timing of COVID-19 transmission. *MedRxiv*, 2020. Available: https://www.medrxiv.org/content/10.1101/2020.09.04.20188516v2/ [Accessed Oct 2020].
5 Gandhi M, Yokoe DS, Havlir DV. Asymptomatic transmission, the Achilles' heel of current strategies to control Covid-19. *N Engl J Med* 2020;382(22):2158–-2160.
6 Washington Post. Coronavirus Live Updates [Internet], 2020. Available: https://www.washingtonpost.com/nation/2020/10/09/coronavirus-covid-live-updates-us/ [Accessed Oct 2020].
7 Hanson R. Overcoming Bias: Expose The Young [Internet]. Overcomingbias.com, 2020. Available: https://www.overcomingbias.com/2020/03/expose-the-young.html/ [Accessed Oct 2020].
8 Wu K. What Does 'Negative' on a Coronavirus Test Really Mean? [Internet]. *New York Times*, 2020. Available: https://www.nytimes.com/2020/10/15/health/coronavirus-testing-negative.html/ [Accessed Oct 2020].
9 Centers for Disease Control and Prevention (CDC). Coronavirus Disease 2019 (COVID-19): Isolate If You Are Sick [Internet], 2020. Available: https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/isolation.html/ [Accessed Oct 2020].
10 Gudbjartsson DF, Norddahl GL, Melsted P, *et al*. Humoral immune response to SARS-CoV-2 in Iceland. *N Engl J Med* 2020;383(18):1724–34.
11 McKenna S. What immunity to COVID-19 really means. *Sci Am*, 2020. Available: https://www.scientificamerican.com/article/what-immunity-to-covid-19-really-means/ [Accessed Jun 2020].
12 Finkenstadt DJ, Handfield R, Guinto P. Why the U.S. still has a severe shortage of medical supplies. Harvard business review, 2020. Available: https://hbr.org/2020/09/why-the-u-s-still-has-a-severe-shortage-of-medical-supplies/ [Accessed Oct 2020].
13 Simmons-Duffin S. States Nearly Doubled Plans For Contact Tracers Since NPR Surveyed Them 10 Days Ago. *National Public Radio (NPR)*, 2020. Available: https://www.npr.org/sections/health-shots/2020/04/28/846736937/we-asked-all-50-states-about-their-contact-tracing-capacity-heres-what-we-learne/ [Accessed Jun 2020].
14 Ollstein AM, Ravindranath M. Getting it right: States struggle with contact tracing push. *Politico*, 2020. Available: https://www.politico.com/news/2020/05/17/privacy-coronavirus-tracing-261369/ [Accessed Jun 2020].
15 Tromberg BJ, Schwetz TA, Pérez-Stable EJ, *et al*. Rapid Scaling Up of Covid-19 Diagnostic Testing in the United States - The NIH RADx Initiative. *N Engl J Med* 2020;383(11):1071–7.
16 Farmer B. At least 9,000 U.S. health care workers Sickened with COVID-19, CDC data shows. National public radio (NPr), 2020. Available: https://www.npr.org/sections/health-shots/2020/04/15/834920016/at-least-9-000-u-s-health-care-workers-sickened-with-covid-19-cdc-data-shows/ [Accessed Jun 2020].
17 CDC COVID-19 Response Team. Characteristics of Health Care Personnel with COVID-19 - United States, February 12-April 9, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69(15):477–81.
18 Lai X, Wang M, Qin C, *et al*. Coronavirus disease 2019 (COVID-2019) infection among health care workers and implications for prevention measures in a tertiary hospital in Wuhan, China. *JAMA Netw Open* 2020;3(5):e209666.
19 Kluytmans-van den Bergh MFQ, Buiting AGM, Pas SD, *et al*. Prevalence and clinical presentation of health care workers with symptoms of coronavirus disease 2019 in 2 Dutch hospitals during an early phase of the pandemic. *JAMA Netw Open* 2020;3(5):e209673.
20 Wang Z, Ma W, Zheng X, *et al*. Household transmission of SARS-CoV-2. *J Infect* 2020;S0163-4453(20):30169–9.
21 Berg S. How doctors can keep their families safe after providing COVID-19 care. American Medical association, 2020. Available: https://www.ama-assn.org/practice-management/physician-health/how-doctors-can-keep-their-families-safe-after-providing-covid/ [Accessed Jun 2020].
22 Ellis EG. How Health Care Workers Avoid Bringing Covid-19 Home. *Wired*, 2020. Available: https://www.wired.com/story/coronavirus-covid-19-health-care-workers-families/ [Accessed Jun 2020].
23 Esty-Kendall J, Kerwin C, Bowman E. In Self-Isolation, A Doctor Deepens His Connection to His Family. *National Public Radio (NPR)*, 2020. Available: https://www.npr.org/2020/05/29/863429741/in-self-isolation-a-doctor-deepens-his-connection-to-his-family/ [Accessed Jun 2020].
24 Guarino B. Nurses, doctors take extreme precautions to avoid infecting family members. *Washington Post*, 2020. Available: https://www.washingtonpost.com/

health/2020/04/16/nurses-doctors-are-taking-extreme-precautions-avoid-bringing-coronavirus-home/ [Accessed Jun 2020].
25 Yourish K, Rebecca KK. One-Third of all U.S. coronavirus deaths are nursing home residents or workers. New York times, 2020. Available: https://www.nytimes.com/interactive/2020/05/09/us/coronavirus-cases-nursing-homes-us.html [Accessed Jun 2020].
26 Centers for Disease Control and Prevention (CDC). Coronavirus disease 2019 (COVID-19): cases in the U.S, 2020. Available: https://covid.cdc.gov/covid-data-tracker/#health-care-personnel [Accessed Sept 2020].
27 Liu Y, Yan L-M, Wan L, *et al*. Viral dynamics in mild and severe cases of COVID-19. *Lancet Infect Dis* 2020;20(6):656–7.
28 Shah SK, Miller FG, Darton TC, *et al*. Ethics of controlled human infection to address COVID-19. *Science* 2020;368(6493):832–4.
29 Eyal N, Lipsitch M, Smith PG. Human challenge studies to accelerate coronavirus vaccine licensure. *J Infect Dis* 2020;221(11):1752–-1756.
30 Hu Z, Song C, Xu C, *et al*. Clinical characteristics of 24 asymptomatic infections with COVID-19 screened among close contacts in Nanjing, China. *Sci China Life Sci* 2020;63(5):706–-711.
31 McAuley J. Students in France return to schools even as covid-19 cases soar [Internet]. *Washington Post*, 2020. Available: https://www.washingtonpost.com/world/europe/covid-schools-reopen-france/2020/08/31/21afbd94-e93e-11ea-bf44-0d31c85838a5_story.html [Accessed Oct 2020].
32 Paulus S. Coronavirus: is it safe for children to return to school? *The Conversation* 2020.
33 National Centre for Immunisation Research and Surveillance (NCIRS). Report: COVID-19 in schools – the experience in NSW. Available: http://ncirs.org.au/covid-19-in-schools/ [Accessed Jun 2020].
34 Flaherty S. Mass General study finds children have high COVID-19 viral load despite mild or no symptoms. Massachusetts General Hospital press release, 2020. Available: https://www.massgeneral.org/news/press-release/Massachusetts-general-hospital-researchers-show-children-are-silent-spreaders-of-virus-that-causes-covid-19/ [Accessed Oct 2020].
35 Faden R, Collins M. Let's Be Honest About the Ethical Trade-Offs of Reopening Schools. *Education Week*, 2020. Available: https://www.edweek.org/ew/articles/2020/05/08/lets-be-honest-about-the-ethical-trade-offs.html/ [Accessed Jun 2020].
36 Yglesias M. Prolonged school closures could be very costly for America's students. *Vox*, 2020. Available: https://www.vox.com/2020/4/21/21223585/school-closure-impact-students-children/ [Accessed Jun 2020].
37 American Academy of Pediatrics. Children and COVID-19: State-Level data report, 2020. Available: https://services.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/children-and-covid-19-state-level-data-report/ [Accessed Oct 2020].
38 Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. *JAMA* 2020;323(13):1239–42.
39 Dong Y, Mo X, Hu Y, *et al*. Epidemiology of COVID-19 among children in China. *Pediatrics* 2020;145(6). doi:10.1542/peds.2020-0702. [Epub ahead of print: 16 03 2020] https://pediatrics.aappublications.org/content/145/6/e20200702/
40 Kim L, Whitaker M, O'Halloran A, *et al*. Hospitalization Rates and Characteristics of Children Aged <18 Years Hospitalized with Laboratory-Confirmed COVID-19 - COVID-NET, 14 States, March 1-July 25, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69(32):1081–8.
41 Shekerdemian LS, Mahmood NR, Wolfe KK, *et al*. Characteristics and outcomes of children with coronavirus disease 2019 (COVID-19) infection admitted to US and Canadian pediatric intensive care units. *JAMA Pediatr* 2020;174(9):868–73.
42 Centers for Disease Control and Prevention (CDC). Multisystem inflammatory syndrome (MIS-C): cases in the U.S, 2020. Available: https://www.cdc.gov/mis-c/cases/index.html/ [Accessed Oct 2020].
43 COVID-19 Host Genetics Initiative. The COVID-19 host genetics initiative, a global initiative to elucidate the role of host genetic factors in susceptibility and severity of the SARS-CoV-2 virus pandemic. *Eur J Hum Genet* 2020;28(6):715–8.
44 New York Times. Tracking COVID at U.S. colleges and universities, 2020. Available: https://www.nytimes.com/interactive/2020/us/covid-college-cases-tracker.html [Accessed Oct 2020].
45 Nierenberg A, Pasick A. Schools Briefing: University Outbreaks and Parental Angst. *New York Times*, 2020. Available: https://www.nytimes.com/2020/08/19/us/colleges-closing-covid.html [Accessed Oct 2020].
46 Centers for Disease Control and Prevention (CDC). Coronavirus disease 2019 (COVID-19): your health – long-term effects, 2020. Available: https://www.cdc.gov/coronavirus/2019-ncov/long-term-effects.html/ [Accessed Oct 2020].
47 Chan S. Inmates at one California jail tried to infect themselves with coronavirus, Los Angeles Sheriff says. *Cable News Network (CNN)*, 2020. Available: https://www.cnn.com/2020/05/11/us/california-inmates-coronavirus-self-infection/index.html/ [Accessed Jun 2020].
48 Marcus J. Americans Aren't Getting the Advice They Need. The Atlantic, 2020. Available: https://www.theatlantic.com/ideas/archive/2020/05/no-one-telling-americans-how-reopen-their-lives/612172/ [Accessed Jun 2020].
49 Gordon E. What's The Evidence That Supervised Drug Injection Sites Save Lives? National Public Radio (NPR), 2018. Available: https://www.npr.org/sections/health-shots/2018/09/07/645609248/whats-the-evidence-that-supervised-drug-injection-sites-save-lives/ [Accessed Jun 2020].
50 Wagener D. Harm Reduction - Treatment for Heroin Addiction - Alcoholism. DrugAbuse.com, 2019. Available: https://drugabuse.com/harm-reduction/ [Accessed Jun 2020].