Received: 10 February 2019 | Accepted: 26 February 2019

DOI: 10.1111/ctr.13519

SPECIAL ISSUE-TRANSPLANT INFECTIOUS DISEASES

WILEY Clinical TRANSPLANTATION
The Journal of Clinical and Translational Research

Strategies for safe living following solid organ transplantation—Guidelines from the American Society of Transplantation Infectious Diseases Community of Practice

Robin K. Avery[1] | **Marian G. Michaels**[2] | **on behalf of the AST Infectious Diseases Community of Practice**

[1]Division of Infectious Disease (Transplant/Oncology), Johns Hopkins, Baltimore, Maryland

[2]Division of Pediatric Infectious Diseases, UPMC Children's Hospital of Pittsburgh, Pittsburgh, Pennsylvania

Correspondence
Robin K. Avery, Division of Infectious Disease (Transplant/Oncology), Johns Hopkins, Baltimore, MD.
Email: ravery4@jhmi.edu
and
Marian G. Michaels, Division of Pediatric Infectious Diseases, UPMC Children's Hospital of Pittsburgh, Pittsburgh, PA.
Email: Michmg@upmc.edu

Abstract

The present AST-IDCOP guidelines update information on strategies for safe living after organ transplantation. While transplantation carries an increased risk for infection from the recipient's environment due to lifelong immunosuppression, the goal is for the recipient to be able to return to their home and live as normal a life as possible with a functioning graft. The current guideline provides updates to prior recommendations including additions on infections from water and food sources, exposures to animals, cannabis use as well as sexual exposures or those encountered with travel. Similar to the prior editions, many of the recommendations are based on good infection prevention standards, extrapolation from other immunocompromised hosts, and risks found from cases series in transplant patients. Enhanced education and attention to incorporating safe living strategies into daily life should help to accomplish successful transplant with recipients achieving a fulfilling life away from the hospital.

KEYWORDS

complication, guidelines, infection and infectious agents, infectious, infection prevention

1 | INTRODUCTION

Infections remain a risk to the recipients of solid organ transplantation, long after the initial post-transplant period. Factors that affect risk include the recipient's net state of immunosuppression, epidemiologic exposures, and the consequences of the invasive procedures to which the recipient has been subjected.[1-4] Infections can be due to endogenous organisms that reactivate during periods of excess immunosuppression, donor-acquired organisms[5] (see Donor Derived Infection section of 4th edition of AST ID Guidelines), or from the environment, whether it be in the hospital setting or the community after discharge. They may also develop opportunistic infections with exogenously acquired organisms if exposed particularly to a high inoculum or virulent microbe, even during periods of minimal or maintenance immunosuppression. A major goal of transplantation is to be able to lead as healthy and normal a life as possible; accordingly, the risk of exposure to infectious agents will always be present. However, various measures can be taken to reduce high-risk epidemiologic exposures in the hospital and in the community, and transplant recipients should be counseled in ways to minimize the risk of infection. Furthermore, strategies for safe living must be carefully woven into the transplant recipient's life as they move toward regaining normal function and return to an active and productive life.

Information on specific infections is available in other sections of these Guidelines, whereas this section will deal with infectious exposures that are encountered in daily life. Unfortunately, "hard data" and controlled studies regarding safe living practices following solid organ transplantation are lacking in many areas. Guidelines for preventing opportunistic infections in other immunocompromised

© 2019 John Wiley & Sons A/S. Published by John Wiley & Sons Ltd

populations such as hematopoietic stem cell transplant recipients[4] and in persons infected with human immunodeficiency virus[6] have been drafted by various working groups that include the Centers for Disease Control and Prevention, Infectious Diseases Society of America, United States Public Health Service, and American Society of Blood and Marrow Transplantation, and can be extrapolated to the solid organ transplant population. In addition, published guidelines on isolation precautions,[7] hand hygiene,[8] and environmental control of infection[9] provide valuable insights, although they focus primarily on healthcare settings. The following recommendations are based on available knowledge of the mode in which various infectious agents are transmitted, anecdotal clinical experience, the opinions of respected authorities, collections of case reports,[10] and common sense. As such, the quality of evidence for the recommendations is often low quality due to the inability to perform randomized controlled studies. This takes into account the general recognition that solid organ transplant recipients are at greatest risk of infection during the first 6-12 months after transplantation or when their immunosuppression is augmented for episodes of rejection. During the early post-transplant period and times of intensified immunosuppression, it is, therefore, appropriate to exercise increased vigilance and very rigorous adherence to guidelines, whereas it is possible that some of these guidelines may be more loosely interpreted for patients further out in time from transplant who are clinically well and receiving minimized immunosuppression. Finally, it should be emphasized that guidelines for the prevention of infection in solid organ transplant recipients should be tailored to the individual recipient by their healthcare providers with special consideration of the patient's degree of immunosuppression, patient values and preferences, financial limitations, and other personal circumstances.

2 | PREVENTION OF INFECTIONS TRANSMITTED BY DIRECT CONTACT

Most organisms are acquired from direct contact (particularly on hands or from fomites), ingestion, or inhalation. Frequent and thorough hand washing is imperative as a means of preventing infections that are transmitted by direct contact. Hands should be washed with soap and water. Hygienic hand rubs are an acceptable alternative for maintaining clean hands, except when there is visible soiling of the hands or when contact is made with norovirus or organisms that are known to have a spore stage (eg, *Clostridium difficile*).[8] Gloves should be worn whenever handling heavily contaminated materials such as soil, moss, or manure. Going barefoot outside should be avoided. Shoes, socks, long pants, and long-sleeved shirts should be worn while doing gardening, yard work, farming, or being in parks or wooded areas.

Hands should be washed (including after gloves are used) (strong, moderate):

- Before preparing food and before eating.
- Before and after touching wounds (whether or not gloves are used).
- Before touching mucous membranes.
- After touching or cleaning up after pets and animals.
- After gardening or touching plants or soil.
- After changing diapers (though ideally, other family members should change diapers rather than the transplant recipient).
- After touching secretions and excretions, including nose-blowing.
- AFTER touching items that have had contact with human or animal feces, (eg, bedpans, bedding, toilets, litter boxes).

In addition, there is considerable potential for transmission of infections via percutaneous exposures. Transplant recipients should avoid intravenous or intradermal use of illicit drugs, not only due to the health consequences of using such drugs, but also the risk of acquiring blood transmitted infections such as HIV, HCV, and HBV. Body piercings and tattoos represent a break in the skin, which can lead to infection as well,[10] and are not encouraged. If body piercing or tattoos are to be obtained, reputable centers should be used and close attention to sterile technique employed. Self-piercing or tattooing or sharing of needles should be avoided.

Cleaning and disinfection of environmental surfaces in the home should take into account the fact that *C difficile* and norovirus are resistant to some commonly used disinfectants. Bleach-based household cleaners are the most effective for *C difficile* and norovirus. If an individual in the home has a diarrheal illness, whether it is the transplant recipient, or a household contact, rubber, or disposable gloves and a bleach-based cleaner should be used on environmental surfaces, particularly on bathroom and kitchen surfaces. The CDC website[11] includes a video on how to clean up after vomiting and diarrhea from a person with norovirus infection.

3 | PREVENTION OF RESPIRATORY INFECTIONS

Microbes that cause respiratory infections are transmitted by either inhalation of aerosolized organisms or direct contact from contaminated hands to mucous membranes. Accordingly, transmission of respiratory pathogens can be reduced by the following measures: (strong, low to moderate):

- Frequent and thorough hand washing, particularly prior to touching mucous membranes.
- Avoiding close contact with persons with respiratory illnesses. If contact is unavoidable, ideally both the infected person and the transplant recipient should wear a standard surgical mask.
- Avoiding crowded areas, such as shopping malls, subways, elevators, where close contact with persons with respiratory illness is likely. Though continually avoiding these areas is unrealistic, caution is advised during periods of enhanced immunosuppression. Likewise, caution should be increased when viruses are circulating in the community such as epidemic influenza.
- Avoiding tobacco smoke. Smoking and exposure to environmental tobacco smoke are risk factors for bacterial and community-acquired viral infections.

- Marijuana smoking or vaporization of the plant product should also be avoided because of its association with exposure to fungal spores from *Aspergillus* spp and other organisms. While use of medical marijuana is becoming more common, transplant recipients should be aware that medical marijuana (the plant product) obtained from dispensaries has been found to contain multiple types of fungi and Gram-negative bacteria including ones with multidrug resistance.[12] Although further data are awaited, it is likely that oral ingestion of baked cannabis products or use of marijuana derivatives other than the plant product (such as oils) would not pose the same level of risk as smoking or vaporization of the plant product.
- Avoiding exposure to persons with known active tuberculosis and avoiding activities and occupational settings that increase the risk of exposure to tuberculosis, for example, working in prisons, jails, homeless shelters, and certain healthcare settings.
- Avoiding, if possible, other occupational risks including working in certain animal care settings, construction, gardening, landscaping, and farming. Decisions to work in high-risk areas should be made by the patient after consultation with the transplant team and primary care physicians so that the risks and benefits can be appropriately discussed, and precautions implemented if the patient chooses to accept these risks.
- Avoiding construction sites, excavations, or other dust-laden environments where there may be a high concentration of spores from molds (eg, *Aspergillus*, *Histoplasma*).
    - Home remodeling projects which may lead to increased risk of Aspergillus in the environment need to be planned cautiously. While data are not available on specific risk, it would be prudent for the transplant recipient to avoid exposure particularly early after transplantation or rejection treatment or after lung transplantation. While clinicians may counsel patients to temporarily move out of their homes when visible mold is detected and during mold-abatement procedures, the level of infectious risk is not known.
- Avoiding exposure to fungal spores (*Cryptococcus*, *Histoplasma*, etc) by avoiding plant and soil aerosols (such as mulching), pigeon, and other bird droppings, chicken coops, and caves.
- Consideration for wearing a mask if exposure to above high-risk areas is unavoidable.

4 | WATER SAFETY/EXPOSURE TO *CRYPTOSPORIDIUM*

Waterborne infections most often occur from consumption of contaminated drinking water or inadvertent water ingestion during recreational activities such as swimming, diving, or boating. Less frequently, infection can result from inhalation or direct contamination of the eye or a wound. A CDC report of infection outbreaks related to treated recreational water between 2000 and 2014 identified *Cryptosporidium* as the most common cause out of 363 outbreaks with confirmed infectious causes.[13] *Cryptosporidium* was the cause in 58% of outbreaks, followed by *Legionella* (16%), *Pseudomonas* (13%), and a variety of other pathogens.[13] Treated recreational water refers to pools, hot tubs/spas, water parks, and interactive water play venues, and should conform to standards established in the CDC's Model Aquatic Health Code, or MAHC.[14] In the above report, hotels were the most common setting, for treated recreational waterborne outbreaks, in association with hot tubs/spas, with *Pseudomonas* being the most common hotel water-associated pathogen.[13]

Cryptosporidium has long been known to cause severe, chronic diarrheal disease in immunocompromised hosts, particularly those receiving corticosteroids,[15-18] and has been increasingly reported in solid organ transplant recipients.[16-18] In a study of organ transplant recipients with cryptosporidiosis by Bonatti et al,[17] an association was noted with elevated tacrolimus levels and acute kidney injury. Environmental risk factors were identified in 18/47 (38%) of organ transplant recipients with cryptosporidiosis in the TRANSCRYPTO nationwide study in France.[18] *Cryptosporidium* is resistant to chlorine and other chemicals and can be problematic even with treated water sources[13] Therefore, it is prudent for solid organ transplant recipients to decrease their exposure to this pathogen as well as others that might be found in water sources. Even treated municipal tap water may not be completely free of *Cryptosporidium*; however, there are no data to support a recommendation that all tap water be avoided unless a "boil water" advisory is issued by local authorities. To completely eliminate the risk of *Cryptosporidium* contamination, one should only drink water that has come to a rolling boil for at least 1 or 3 minutes at elevations above 6500 feet.[13] Persons avoiding untreated tap water should be reminded that ice, and fountain beverages served at restaurants, bars, theaters, sporting events, etc, are prepared with tap water. Personal-use filters and/or bottled water may serve as alternatives to boiling water to eradicate *Cryptosporidium* and other waterborne pathogens, but careful attention must be paid to selecting effective filters and high-quality bottled water. Transplant recipients who are selecting filters should look for filters with absolute pore size of <1 micron, or filters tested and certified to NSF/ANSI Standard 053.[19] Further information regarding NSF-certified filters for cryptosporidial cyst removal may be obtained on the NSF website http://info.nsf.org/Certified/dwtu/ (select NSF Standard 053)[20] or by calling the NSF international consumer line at 800-673-8010. Information regarding bottled water can be obtained from the International Bottled Water Association at 703-683-5213 or (http://www.bottledwater.org).[21] The CDC also has a webpage devoted to bottled water technologies in relationship to cryptosporidiosis risk [22]; https://www.cdc.gov/parasites/crypto/gen_info/bottled.html.

For individuals who have treated water supplies, the expense of buying bottled water is usually not warranted.

Specific recommendations for water safety include (strong, low to moderate):

- Close attention should be paid to directions given during local governmental recommendations for "boil water" advisories for any waterborne pathogen.

  - 3During outbreaks having the water come to a rolling boil for at least 1 minute is advisable.
- Well water from private or public wells in areas that are not screened frequently for bacterial pathogens should be avoided if possible because of potential risk of *Cryptosporidium*, *Giardia*, and bacterial coliform contamination. If well water is used, it should be tested yearly for microbial contamination (However, it is even safer to boil well water or use bottled water for drinking and brushing teeth).
- Transplant recipients should not drink water directly from lakes or rivers because of the risk of *Cryptosporidium*, *Giardia*, and bacterial coliform contamination.
- Waterborne infection might also arise from inadvertent swallowing of water during recreational activities such as swimming in lakes, rivers, or pools, using hotel or motel pools or spas, or going on water rides at amusement parks. Transplant recipients should avoid swimming in water that is likely to be contaminated with human or animal waste, and should avoid swallowing water during swimming.
- To avoid spreading infection to others, transplant recipients who have had diarrhea should not use public recreational water facilities for 2 weeks after symptoms have resolved.
- Hot tubs have been associated with several infection risks,[13,23,24] including *Pseudomonas* folliculitis, legionellosis, and mycobacterial infections; and should be avoided.
- Standing water in the home or basement, such as may occur with flooding, should be promptly cleaned up to avoid growth of mold, *Legionella*, and other pathogens. Ideally, someone other than the transplant recipient should perform the cleaning. If the transplant recipient cannot avoid exposure then waterproof boots and gloves and a mask should be worn during the cleaning process.
- When traveling to countries with poor sanitation, drinking tap water as well as inadvertent consumption from ice cubes, brushing teeth, or during showering should be avoided.
- Abrasions incurred during bathing in ocean or fresh water should be thoroughly cleaned with an uncontaminated water source due to risk of infection with organisms such as *Vibrio* species, *Mycobacterium marinum*, or *Aeromonas* spp.

5 | FOOD SAFETY

In addition to food-associated pathogens traditionally recognized as threats to transplant recipients, such as Listeria and Salmonella spp, there have been increasing reports in the last 5 years of a severe, relapsing, chronic diarrheal syndrome due to norovirus.[25-27] Norovirus is now the most common food-borne infection in the United States. This CDC website on norovirus prevention has useful information on food preparation and handling.[11]

To minimize risks of food-borne infections, the recommendations below, which also apply to healthy individuals, should be followed. The United States Department of Agriculture (USDA)'s website on food safety[28] is a very user friendly resource to review current outbreaks, recalls, and alerts, safe cooking temperatures for different foods, as well as general food safety recommendations, and explains the four-step safe food handling procedure known as "Clean—Separate—Cook—Chill". In addition, the USDA and the FDA have published a very helpful online brochure on "Food Safety for the Transplant Recipient", which is recommended for patients.

Transplant recipients should avoid: (strong, low to moderate)

- Drinking unpasteurized milk, fruit, or vegetable juice/cider in order to decrease their risk of infection with *Escherichia coli* 0157:H7, *Salmonella*, *Brucella*, *Listeria*, *Yersinia*, and *Cryptosporidium*.
- Eating cheeses made with unpasteurized milk (such as soft cheeses such as brie, camembert, feta, blue cheese, moldy cheese, and others) to decrease the risk of *Listeria*. While most feta cheese in the United States is now pasteurized, not all of it is, and it is still important to check.
- Eating raw or undercooked eggs including foods containing raw eggs (eg, uncooked cake and cookie batter and some preparations of Caesar salad dressing, mayonnaise, or hollandaise sauce) particularly a risk for *Salmonella* infection.
- Eating raw or undercooked meat, poultry, or fish with particular risk not only for bacterial contamination but also for parasitic infections such as *Toxoplasma gondii*, and tapeworms.
- Eating any raw or undercooked seafood (oysters, clams, mussels) to prevent exposure to *Vibrio* species, viruses such as norovirus that cause gastroenteritis or hepatitis, and parasitic infections including *Cryptosporidium*.
- Ingesting raw seed sprouts (alfalfa sprouts, mung beans).
- Cross-contamination when preparing food, (eg, keep cooked and raw foods separate; use cleaned or separate cutting boards washed with hot soapy water in between uses).
- Eating uncooked pate, meat spreads, cold cuts, and smoked seafood.
- Eating from public salad bars or buffets, street vendors, picnics where food has sat out at room temperature, or potluck meals especially if the hygiene standards of all participants are not known.
- Eating any food prepared by someone with a recent diarrheal illness.
  - While not all outbreaks can be anticipated, transplant recipients, and their families should pay particular attention to local recommendations when outbreaks occur to avoid exposure to contaminated foods such as occurred with the widespread *Listeria* outbreak associated with cantaloupe in the United States in 2012 and the outbreak of *E coli* 0104:H4 in Germany in 2011. Food recalls may involve unexpected foods, and the transplant recipient and family may wish to watch for recalls on the CDC's food safety website.[29]

Vaccination against Hepatitis A should be sought before transplant if possible to offer the best protection against hepatitis A as a food-borne virus.

6 | ANIMAL CONTACT AND PET SAFETY

6.1 | Occupational risk

Transplant recipients who work with animals (veterinarians, pet store employees, farmers, slaughterhouse, or laboratory workers) should, if possible, avoid working during periods of maximal immunosuppression. When returning to work, transplant recipients should minimize their exposure to potential pathogens by using proper precautions, including frequent hand hygiene and the use of gloves and masks as indicated below.

6.2 | Pet ownership

Healthcare providers must balance the psychological benefits of pet ownership with potential risks for transmission of infection when counseling solid organ transplant recipients on the safety of maintaining pets. There are a variety of zoonoses that can be transmitted to the transplant recipient from pet animals,[28] and severe infections including *Bordetella bronchiseptica* or "kennel cough",[29] Bartonella or "cat scratch",[30] and Pasteurella,[31] among others, have been reported to occur in transplant recipients in association with household pets (and occasionally in association with pet vaccines). That being said, some studies have documented widespread pet ownership among transplant recipients without risk of infection.[32] One study of 89 lung transplant recipients, including 52% who were pet owners, reported significantly increased metrics of life satisfaction among pet owners, without any increased risk of hospitalizations.[32] It should be noted, however, that in that study, 96% of the pets were obtained pre-transplant and thus were not new pets, and 91% were indoor pets. In any case, the veterinarian should be viewed as a colleague, both to the transplant clinician and the transplant recipient, since maintenance of pet health can help reduce human risk.[33] Advice from veterinarians on pet immunizations can likewise be helpful particularly for live vaccines such as *B bronchiseptica*.

In general, transplant recipients should (strong, low).

- Avoid contact with animals that have diarrhea.
- Keep their pets healthy by feeding them food that is not contaminated or spoiled, and seeking veterinary help at the first signs of illness.
- Take the pet regularly to the veterinarian for checkups.
- Wash hands carefully after handling pets.
- Avoid cleaning bird cages, bird feeders, litter boxes, and handling animal feces. If this is not possible, the use of disposable gloves, and a standard surgical mask should be employed.
- Avoid stray animals.
- Avoid animal bites and scratches (do not pet stray animals).
- Ensure that areas near the home are free of raccoon latrines.
- Avoid contact with nonhuman primates (monkeys).
- Wear gloves to clean aquariums or have someone else in household do the cleaning.
- Consider waiting to acquire a new pet until a period when the patient is on stable immune suppression (at least 6-12 months after transplantation).
- Consider the type of pet and specific risks for infections.
    - Reptiles and amphibians (snakes, iguanas, lizards, and turtles) have a high risk of *Salmonella* infection and should be avoided.[30]
    - Chicks and ducklings have a risk of transmitting *Salmonella* infections and should be avoided.[30]
    - Rodents have a risk of transmitting lymphocytic choriomeningitis virus.
    - Young cats have risk of transmitting *Bartonella henselae*.
    - Cats have a risk of transmitting *T gondii*.
    - Puppies, kittens, and chicks have a risk of transmitting *Campylobacter* infections.
    - Exotic pets are best avoided.[30]
    - Regarding pet vaccines, it is best to confer with the veterinarian. When effective nonlive vaccines exist it is preferable to administer these. If live vaccines are given, (eg, live attenuated vaccine for *B bronchiseptica* [kennel cough]) it would be advisable to not to have the transplant recipient hold the dog during vaccination to avoid direct contact with the vaccine and to pay extra attention to avoiding direct contact with the dogs nose mouth or face after vaccination.

Cats can spread *Toxoplasma*, *Cryptosporidium*, *Salmonella*, *Campylobacter* (contaminated feces), *Bartonella* (fleas and scratches), and Pasteurella (through bites and licking wounds).[28,31] Young cats carry the highest risk for transmitting *Bartonella* (cat scratch).[34] The CDC recommends cat litter boxes should be changed daily (preferably not by transplant recipients), because it takes longer than 24 hours for *Toxoplasma* oocysts to become infectious; they do not comment on the differences in removing clumped cat litter vs changing the entire litter tray. Although dogs are generally considered safer pets than cats, birds, and reptiles, there are documented instances of infections transmitted by dogs without a bite, such as cases of *Bordetella bronchoseptica* (the agent of "kennel cough") in lung transplant recipients.[29] While dogs classically have this disease, kittens likewise can be infected and transmit the bacteria. Both puppies and kittens can transmit *Campylobacter* infections. Birds can transmit infections such as psittacosis or cryptococcosis which may be a particular risk for lung transplant recipients.

Despite the risk of infection from animals, many benefits of pet ownership have been demonstrated and transplant recipients have often had family pets without transmission of infection.[32,33] Attention to hand hygiene after contact and ensuring that pets are in good health should be emphasized.

7 | SAFER SEXUAL PRACTICES

Many infections can be transmitted during sexual contact. Some of these can be reduced by having a long term monogamous relationship or decreasing the number of sexual partners.

Sexually active transplant recipients should (Strong, moderate to high):

- Always use latex condoms during sexual contact outside of long term monogamous relationships to reduce exposure to CMV, hepatitis B and C, HIV, HPV, HSV, and other sexually transmitted infections
- Consider using latex condoms during sexual activity even with long term monogamous partners during periods of increased immunosuppression.
- Avoid exposure to feces during sexual activity.
  - Immunize against HBV and HPV at appropriate ages, and when possible prior to transplantation to achieve greatest efficacy[35] (see Vaccine section of 4th edition of AST ID Guidelines).
- Education in safer sex practices is an important component of medical care, particularly for adolescents with recent or imminent sexual debut.[34,36] Immunization against HPV is particularly warranted in adolescents and young adults and has been shown in immunocompetent individuals to be most efficacious when administered prior to initiation of sexual intercourse. In addition, the vaccine may prevent development of HPV-related malignancies, for which transplant recipients are at increased risk, although data are limited in this population.

8 | TRAVEL SAFETY

Travel can pose substantial infection risks to transplant recipients, particularly during periods of maximal immunosuppression. Comprehensive recommendations can be found in the review by Kotton et al[37] and the sections on Travel Medicine[38] and Parasitic Infections[39,40] in the current AST ID Guidelines.

9 | WORK- AND SCHOOL-RELATED ISSUES

The above sections have touched on many topics relevant to potential infection hazards in the workplace and in school for children. Individualized occupational counseling is important for transplant recipients contemplating return to work in such areas as health care, construction, outdoors work, and other fields. Whereas some recipients may be willing to consider a career change (eg, leaving a temporary job in a pet store), others may be strongly attached to their line of work for multiple reasons such as psychological, financial, or social. In some cases, a return to work is necessary for the transplant recipient to maintain family financial stability and their health insurance. A study by Jain et al[41] showed that 36.9% of 194 lung transplant recipients who completed a survey returned to work and that 55.9% had modified their job, often in order to decrease infection risks. Interestingly, farm work was common in this study despite the potential fungal and other occupational risks.[41] Another study of 61 solid organ and stem cell transplant recipients reported that 56% had returned to work, and 94% reported job modifications, of which 69% were adopted in order to reduce infection risk.[42]

Studies to inform decisions on work are lacking, but the vast majority of jobs can at least be made safer by some simple measures. These include restricting patient contact for the initial phase of returning to work in a healthcare environment, wearing masks when there are potential exposures to fungal spores, respiratory viruses, or other transmissible illnesses, and sometimes reassignment to other duties particularly during periods of intensified immunosuppression. Often coworkers can be encouraged to receive influenza vaccinations to help protect the recipient as well. The clinician can help by adopting an attitude of working with the transplant recipient to make the proposed work situation safer, rather than issuing an unconditional order to change jobs (with occasional exceptions).

School attendance is of major importance for children who have received transplants and often is a concern for the family. For this reason, it is imperative that pediatric transplant teams discuss this issue with parents early during the pre-transplant evaluation and again well in advance of discharge from the hospital so that plans can be made with the schools. The timing of return to school is impacted upon by the type of transplant, the level of immunosuppression and the age of the child. In most cases, children are able to return to school several months after the transplant. It may be prudent, however, to avoid returning to school during influenza season. In general, a close working relationship with the school nurse is needed so that they are aware of any medical issues about the recipient. They can inform families about infectious disease outbreaks and remind classmates about the importance of receiving all of their required vaccinations.

With regards to returning to work and school, transplant recipients should (strong, low):

- Seek guidance from their transplant teams and/or transplant infectious disease consultants regarding the optimal timing of returning to work or school, depending on their degree of immunosuppression and clinical course.
- Seek guidance from their transplant teams and/or transplant infectious disease consultants regarding mitigating potential infectious risks in the workplace, or possibly seeking another job altogether, depending on the occupation, the particular work-related duties, and flexibility (or lack thereof) regarding job modifications.
- Seek guidance from their transplant teams and/or transplant infectious disease consultants regarding reported outbreaks of infections in the workplace or at school.

10 | SPORTS AND RECREATION

The risks of hobbies such as hunting, fishing, scuba diving, or spelunking should be discussed with the transplant recipient.[10] Outdoor recreational activities may increase risk for inhalation of fungal spores, or risk of tick- and mosquito-borne diseases which vary seasonally and

geographically. Specific risks such as histoplasmosis from spelunking, related to bats in caves, should be discussed. The 6- or 12-month follow-up appointment is an ideal time to bring up these subjects, since patients are often feeling better, are eager to expand their range of activities, and may have forgotten the initial education that they received in the early post-transplant period. A question such as "What hobbies and recreational activities are you planning on resuming?" may provide an opportunity for questions, education, and modification of these activities to reduce infection risks.

In general, athletic activities have been noted to be both safe and beneficial for many transplant recipients,[43] with some specific exceptions as discussed below. In addition to the psychological and health benefits to the individual of sporting activities, the existence of the World Transplant Games has been reported to have increased the public's knowledge and favorable opinion of transplantation.[43] Returning to an appropriate level of recreational and athletic activity can help the transplant recipient's self-esteem and guard against depression. Transplant centers often offer specific restrictions related to the outdoors, as mentioned above, and in addition may choose to advise against certain activities due to risk of physical injury, such as rugby and boxing.[44] In addition, the overall physical state and level of immunosuppression of the particular recipient should be considered. Occasionally unexpected consequences might occur, such as the physical effects from direct contact of climbing harnesses with kidney allografts, leading to concern about the possible effects of rock climbing, rappeling, and challenge courses.[45]

A survey of post-transplant recreational activities in 61 transplant recipients revealed that almost half had contact with soil, gardening, yard work, or plants; 34% swam in an ocean, bay, river, or lake; 15% used hot tubs or saunas, and 39% engaged in nonoccupational construction or home repair projects.[46] Whereas these recreational activities likely confer some degree of increased infection risks, more quantitative information on the magnitude of these risks would be helpful in counseling patients in the future.

In general, transplant recipients should (strong, low):

- Seek guidance from their transplant teams regarding sports and athletic activities that they wish to resume (particularly at the 6- and 12-month post-transplant follow-up visits).
- Seek guidance from their transplant teams and/or transplant infectious disease consultants regarding resuming recreational activities which may increase their risk of tick bites, mosquito bites, or exposures to dirt, soil, unchlorinated water, and other potential infection hazards.

11 | PRECAUTIONS TO PREVENT WEST NILE VIRUS AND OTHER MOSQUITO-BORNE INFECTIONS

West Nile virus (WNV) can cause severe disease in transplant recipients, who have a much higher risk of central nervous system involvement than the general population.[47] Other arthropod-transmitted infections can also be severe in immunocompromised hosts.[20,21] Several simple measures can help to prevent infection with these pathogens. For West Nile virus prevention, transplant recipients should avoid going out at dawn or dusk, during peak mosquito feeding, and should use effective insect repellents that contain DEET. On average, the duration of protection offered by DEET at different concentrations is as follows: 5, 4, 2 and 1.5 hours for products with DEET concentrations of 23.8%, 20%, 6.7%, and 4.5%, respectively.[48] In addition, permethrin-treated protective clothing can be worn during the high-risk season and in areas where transmission is occurring. Sources of standing water, such as old tires, should be removed from yards and property belonging to transplant recipients. Specific prophylaxis when traveling to areas with endemic mosquito-borne infections such as malaria is discussed in the sections on Parasitic Infections and Travel Medicine[38-40] and in recent reviews on prevention of dengue, chikungunya, and Zika viruses.[47,48]

12 | PATIENT CONTACTS: FAMILY, FRIENDS, AND HEALTHCARE WORKERS

While prevention of infection is often aimed at interventions applied directly to the recipient (host-related interventions), it is also important to recognize that close contacts can transmit infections that can be particularly harmful to the transplant recipient. Accordingly, it is worth educating close contacts about ways to maintain their own health and avoid contact with recipients when they are ill. All healthcare workers should receive ongoing education about hand hygiene and standard precautions when caring for people in the healthcare environment. Vaccination against influenza is encouraged for everyone but particularly for those involved in the care of transplant recipients. Many institutions have developed mandatory immunization policies against this virus. Vaccines for other infectious agents are also routinely offered by healthcare systems particularly against Hepatitis B virus, measles, mumps, rubella, varicella, and more recently acellular pertussis vaccine as part of diphtheria and tetanus vaccination.[35] All household contacts should be instructed on good hygiene precautions including, hand washing, cough, and sneezing etiquette and covering open wounds. They should all receive yearly influenza vaccination and to ensure that their other standard immunizations are up to date including vaccinations against pertussis, measles, and varicella. Contacts at work and school should also be encouraged to receive their immunizations.

13 | CONCLUSION

With the increasing longevity of transplant recipients, more and more recipients are returning to active lives, to work, and to recreational activities. Inevitably potential infection risks are present with the expansion of permissible activities. Careful thought and detailed patient education can prevent or reduce many of these

risks. Occupational counseling can enable transplant recipients to find safer ways to do the jobs that they love, and that they need to maintain financial stability and insurance coverage. Knowledge of the risks of food, animal exposures, and other environmental exposures can help transplant recipients stay healthier and avoid hospitalizations.

How can we provide more effective education in the future? More frequent discussions with transplant clinicians (eg, at 6 and 12 months post-transplant), and use of written materials at appropriate age and literacy levels, Internet-based materials, and social media[49] will likely increase patient knowledge and compliance. The American Society of Transplantation has designed patient education packets on multiple transplant-related topics,[48] which will soon include information on strategies for safer living. Increasingly, patient advice and participation in development of such materials are transforming practice. Partnerships between the patient and the clinician will hopefully lead to the goal of transplant recipients leading healthy, meaningful, and long lives.

ACKNOWLEDGEMENTS

This manuscript was modified from the Guideline included in the 3rd Edition of the AST Infectious Diseases Guidelines written by Robin Avery and Marian Michaels published in the American Journal of Transplantation 2013;13 (Suppl 4): 304-310, and endorsed by the American Society of Transplantation.

CONFLICT OF INTEREST

None.

REFERENCES

1. Fishman JA. Infection in solid-organ transplant recipients. *N Engl J Med*. 2007;357(25):2601-2614.
2. Rubin RH, Schaffner A, Speich R. Introduction to the Immunocompromised Host Society consensus conference on epidemiology, prevention, diagnosis, and management of infections in solid-organ transplant patients. *Clin Infect Dis*. 2001;33(Suppl 1):S1-S4.
3. Ljungman P, Snydman D, Boeckh M, eds. *Transplant Infections*. Cham, Switzerland: Springer International Publishing; 2016.
4. Tomblyn M, Chiller T, Einsele H, et al. Guidelines for preventing infectious complications among hematopoietic cell transplantation recipients: a global perspective. *Biol Blood Marrow Transplant*. 2009;15(10):1143-1238.
5. Wolfe C, Ison MG. Donor derived infections - guidelines by the American Society of Transplantation Infectious Disease Community of Practice. Clinical Transplantation. 2019.
6. Panel on Opportunistic Infections in HIV-Infected Adults and Adolescents. Guidelines for the prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. 2018. https://aidsinfo.nih.gov/contentfiles/lvguidelines/adult_oi.pdf. Accessed July 29, 2018.
7. Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in health care settings. *Am J Infect Control*. 2007;35(10 Suppl 2):S65-S164.
8. Boyce JM, Pittet D, Healthcare Infection Control Practices Advisory Committee, HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Guideline for hand hygiene in health-care settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Society for Healthcare Epidemiology of America/Association for Professionals in Infection Control/Infectious Diseases Society of America. *MMWR Recomm Rep*. 2002;51(RR-16):1-45.
9. Sehulster L, Chinn RY, CDC, HICPAC. Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep*. 2003;52(RR-10):1-42.
10. Sipsas NV, Kontoyiannis DP. Occupation, lifestyle, diet, and invasive fungal infections. *Infection*. 2008;36(6):515-525.
11. Centers for Disease Control and Prevention. Norovirus: prevention. 2018. https://www.cdc.gov/norovirus/about/prevention.html. Accessed July 29, 2018.
12. Thompson GR, Tuscano JM, Dennis M, et al. A microbiome assessment of medical marijuana. *Clin Microbiol Infect*. 2017;23:269–270.
13. Hlavsa MC, Cikesh BL, Roberts VA, et al. Outbreaks associated with treated recreational water - United States, 2000–2014. *Am J Transplant*. 2018;18(7):1815-1819.
14. Centers for Disease Control and Prevention. 2018 model aquatic health code. https://www.cdc.gov/mahc/editions/current.html. Accessed July 29, 2018.
15. Tzipori S, Widmer G. A hundred-year retrospective on cryptosporidiosis. *Trends Parasitol*. 2008;24(4):184-189.
16. Tran MQ, Gohh RY, Morrissey PE, et al. Cryptosporidium infection in renal transplant patients. *Clin Nephrol*. 2005;63(4):305-309.
17. Bonatti H, Barroso 2nd LF, Sawyer RG, Kotton CN, Sifri CD. Cryptosporidium enteritis in solid organ transplant recipients: multicenter retrospective evaluation of 10 cases reveals an association with elevated tacrolimus concentrations. *Transpl Infect Dis*. 2012;14(6):635-648.
18. Lanternier F, Amazzough K, Favennec L, et al. Cryptosporidium spp. infection in solid organ transplantation: the Nationwide "TRANSCRYPTO" study. *Transplantation*. 2017;101(4):826-830.
19. Centers for Disease Control and Prevention. Parasites; Cryptosporidium; a guide to water filters. 2018. https://www.cdc.gov/parasites/crypto/gen_info/filters.html. Accessed July 29, 2018.
20. Clemente WT, Pierrotti LC, Abdala E, et al. Recommendations for management of endemic diseases and travel medicine in solid-organ transplant recipients and donors: latin America. *Transplantation*. 2018;102(2):193-208.
21. Morris MI, Grossi P, Nogueira ML, Azevedo LS. Arboviruses recommendations for solid-organ transplant recipients and donors. *Transplantation*. 2018;102(2S Suppl 2):S42-S51.
22. American Academy of Pediatrics. Insect bite and repellant safety tips from the American Academy of Pediatrics. 2018. https://www.aap.org/en-us/about-the-aap/aap-press-room/news-features-and-safety-tips/Pages/Insect-Bite-an. Accessed July 29, 2018.
23. Thomas DL, Mundy LM, Tucker PC. Hot tub legionellosis. Legionnaires' disease and Pontiac fever after a point-source exposure to *Legionella pneumophila*. *Arch Intern Med*. 1993;153(22):2597-2599.
24. Aksamit TR. Hot tub lung: infection, inflammation, or both? *Semin Respir Infect*. 2003;18(1):33-39.
25. Lee LY, Ladner DP, Ison MG. Norovirus infection in solid organ transplant recipients: a single-center retrospective study. *Transpl Infect Dis*. 2016;18(6):932-938.

26. Chong PP, van Duin D, Sonderup JL, Grant WJ, Kalil AC, Florescu DF. Predictors of persistent diarrhea in norovirus enteritis after solid organ transplantation. *Clin Transplant*. 2016;30(11):1488-1493.
27. Avery RK, Lonze BE, Kraus ES, Marr KA, Montgomery RA. Severe chronic norovirus diarrheal disease in transplant recipients: clinical features of an under-recognized syndrome. *Transpl Infect Dis*. 2017;19(2):e12674.
28. Kotton CN. Zoonoses in solid-organ and hematopoietic stem cell transplant recipients. *Clin Infect Dis*. 2007;44(6):857-866.
29. Ner Z, Ross LA, Horn MV, et al. *Bordetella bronchiseptica* infection in pediatric lung transplant recipients. *Pediatr Transplant*. 2003;7(5):413-417.
30. Antar A, Goyal A, Murphy K, et al. Disseminated cat-scratch disease presenting as nausea, diarrhea, and weight loss without fever in a heart transplant recipient. *Transpl Infect Dis*. 2017;19(3):e12678.
31. Christenson ES, Ahmed HM, Durand CM. *Pasteurella multocida* infection in solid organ transplantation. *Lancet Infect Dis*. 2015;15(2):235-240.
32. Irani S, Mahler C, Goetzmann L, Russi Ew, Boehler A. Lung transplant recipients holding companion animals: impact on physical health and quality of life. *Am J Transplant*. 2006;6(2):404-411.
33. Wong SK, Feinstein LH, Heidmann P. Healthy pets, healthy people. *J Am Vet Med Assoc*. 1999;215(3):335-338.
34. Ashoor IF, Dharnidharka VR. Sexually transmitted infection screening and reproductive health counseling in adolescent renal transplant recipients: perceptions and practice patterns. A study from the Midwest Pediatric Nephrology Consortium. *Pediatr Transplant*. 2015;19(7):704-708.
35. Danziger-Isakov L, Kumar D. Vaccination of solid organ transplant candidates and recipients - guidelines by the American Society of Transplantation Infectious Disease Community of Practice. Clinical Transplantation.2019.
36. Sucato GS, Murray PJ. Gynecologic health care for the adolescent solid organ transplant recipient. *Pediatr Transplant*. 2005;9(3):346-356.
37. Kotton CN. Travel and transplantation: travel-related diseases in transplant recipients. *Curr Opin Organ Transplant*. 2012;17(6):594-600.
38. Buchan CA, Kotton CN. Travel medicine, transplant tourism, and the solid organ transplant recipient – guidelines by the American Society of Transplantation Infectious Disease Community of Practice. Clinical Transplantation.2019.
39. Morris MI, LaHoz R.Intestinal parasites including Cryptosporidium, Cyclospora, Giardia, & Microsporidia, Entamoeba histolytica, Strongyloides, Schistosomiasis, & Echinococcus - guidelines by the American Society of Transplantation Infectious Disease Community of Practice. Clinical Transplantation. 2019.
40. Morris MI, LaHoz R. Tissue and blood protozoa including toxoplasmosis, Chagas disease, Leishmaniasis, Babesia, Acanthamoeba, Balamuthia, & Naegleria - guidelines by the American Society of Transplantation Infectious Disease Community of Practice. Clinical Transplantation.2019.
41. Jain A, Humar A, Lien D, Weinkauf J, Kumar D. Strategies for safe living among lung transplant recipients: a single-center survey. *Transpl Infect Dis*. 2015;17(2):185-191.
42. Avery R, Ostrander D, Shoham S, et al. *Return to Work and Occupational Infection Risks in Transplant Recipients*. Philadelphia, PA: American Transplant Congress; 2015.
43. Slapak M. Sport and transplantation. *Ann Transplant*. 2005;10(1):60-67.
44. Heffernan A, Gill D. Sporting activity following kidney transplantation. *Pediatr Nephrol*. 1998;12(6):447-448.
45. Welch TR. Climbing harness fit in kidney transplant recipients. *Wilderness Environ Med*. 1999;10(1):3-5.
46. Avery R, Ostrander D, Shoham S, et al. *Recreational and Lifestyle Infection Risks in Transplant Recipients*. Philadelphia, PA: American Transplant Congress; 2015.
47. Kumar D, Prasad G, Zaltzman J, Levy GA, Humar A. Community-acquired West Nile virus infection in solid-organ transplant recipients. *Transplantation*. 2004;77(3):399-402.
48. American Society of Transplantation. Patient education packets. 2018. https://www.myast.org/patient-information/patient-education-packets. Accessed July 29, 2018.
49. Mouelhi Y, Alessandrini M, Pauly V, Dussol B, Gentile S. Internet and social network users' profiles in Renal Transplant Recipients in France. *BMC Nephrol*. 2017;18(1):259.

How to cite this article: Avery RK, Michaels MG; on behalf of the AST Infectious Diseases Community of Practice. Strategies for safe living following solid organ transplantation—Guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. *Clin Transplant*. 2019;33:e13519. https://doi.org/10.1111/ctr.13519