



## Review

## Mass migration and climate change: Dermatologic manifestations

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## ABSTRACT

Major changes in climate resulting in mass migrations have unique dermatologic implications for global vulnerable populations. Dermatologic manifestations commonly accompany the infectious and communicable diseases that proliferate in the settings of confinement, crowding, and limited sanitation associated with mass migration. Ectoparasitic infestations abound in refugee camps, and poor nutrition, hygiene, and compromised immunity put refugees at an increased risk for more dangerous infectious diseases carried by these ectoparasites. Climate change also profoundly affects the worldwide distribution of various vector-borne illnesses, thereby leading to the emergence of various communicable diseases in previously nonendemic areas. Natural disasters not only disrupt important lifesaving treatments, but also challenge various infectious disease control measures that are critical in preventing rapid transmission of highly infectious diseases. This article reviews the infectious diseases commonly found in these scenarios and provides an in-depth discussion of important implications for the dermatologist.

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## Introduction

Global climate change is likely to create long-term, sudden, and unpredictable weather events, such as heavy rainfall, mass flooding, longer wildfire seasons, and stronger, more frequent hurri-

canes. Extreme weather events could lead not only to property damage and loss of human life, but also to rapid displacement of those who survive ([National Academy of Sciences, 2020](#)). The World Bank estimates that between Latin America, sub-Saharan Africa, and Southeast Asia, 143 million people are likely to be forced into migration due to extreme weather events in the coming year ([Rigaud et al., 2018](#)). In 2013, at least 7 million people in Southeast Asia were forced to migrate due to extreme weather events; as of 2017, it is thought that approximately 22 to 24 mil-

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lion people worldwide have migrated for similar reasons (McDonnell, 2018; Nansen Initiative Secretariat, 2015).

An even larger portion of people are projected to migrate because of slowly rising sea levels, increased air pollution, shifting patterns of precipitation, biodiversity loss, and resulting famines (Podesta, 2020). The United Nations declared climate change the single greatest threat to the livelihoods, security, and wellbeing of Pacific Islanders. Many Pacific Islanders have pleaded with their surrounding larger countries to rapidly introduce higher emission reduction targets (Hollingsworth, 2019). Other climate-related weather pattern changes, such as El Niño, have resulted in such severe droughts that they have fueled international food shortages leading to mass migration (National Geographic, 2018).

Mass migration, either suddenly in the case of extreme weather events or slowly in the case of famine and food shortages, can lead to long periods of confinement and overcrowding. Displacement and long-term confinement in turn lead to the spread of communicable diseases. Ectoparasites, such as scabies and lice, thrive in areas of human concentration and poor hygiene while more serious conditions, such as HIV infection and tuberculosis (TB), can pose a significant threat to the health of migrants. Herein, we review some of these conditions and instances in which confinement, mass migration, and climate changes have led to their proliferation.

## Disease proliferation

### Scabies

Scabies is a common communicable parasitic infestation caused by an arthropod, *Sarcoptes scabiei*. Scabies is endemic worldwide but especially common in areas of confinement (Karimkhani et al., 2017). The mite lives its entire life cycle on humans and burrows into the skin to feed or lay eggs; 5 to 15 scabies mites live on a host at any time, but small numbers can lead to significant symptoms (Chosidow, 2006). The primary mode of transmission is skin-to-skin contact; as such, scabies outbreaks abound in congregate living institutions (prisons, shelters, nursing homes, hospitals) and other crowded areas. Clinical manifestations of scabies include intense pruritus primarily in the genitals, buttocks, abdomen, hands, and other flexor surfaces. Physical examination findings are protean but can include nodules and papules on the penis and scrotum, eczematous plaques on the hands, bullous lesions, and pathognomonic burrow lines where the female scabies mite crawls to lay eggs. In endemic areas, diagnosis is made based on physical examination findings; however, in areas where scabies is less common, scraping the skin burrows and visualizing the scraping under microscopy can reveal the mite or its eggs (Chosidow, 2006). Secondary streptococcal impetigo of scabies infestation is a leading antecedent of poststreptococcal glomerulonephritis worldwide (Chandler and Fuller, 2019).

Crowding, shared living quarters, and limited sanitation contribute to the easy and widespread transmission of scabies among migrants (BBC World News, 2020; Pozzallo et al., 2015). Migrants in tropical climates are especially prone to scabies transmission and are more susceptible to climate-related migration (Micali et al., 2016). For example, scabies and other dermatologic conditions of confinement were noted in migrants and refugees in Europe escaping Syria and Eritrea (Isenring et al., 2018). Treatment of both the patient and close personal contacts is recommended. Topical permethrin (1–2 single applications 1–2 weeks apart) and oral ivermectin (200 mcg/kg single dose with potential repeat dose) are highly effective first-line treatments used in resource-rich settings with close to a 100% cure rate (Chandler and Fuller, 2019). Less costly but also less effective alternatives, such as benzyl

benzoate, topical sulfur, and crotamiton, are often used in resource-scarce settings. These measures could result in ineffective eradication that further perpetuate infestations (Heukelbach and Feldmeier, 2006; Strong and Johnstone, 2007).

### Body lice

The body louse, *Pediculus humanus corporis*, is an ectoparasite that proliferates in high-humidity conditions and is most easily transmitted in settings of poor hygiene, inability to change or wash clothing, and cold weather (due to its association with indoor crowding and infrequent clothing changes; Amanzougaghene et al., 2020). In North America and Europe, body lice typically afflict persons experiencing homelessness (Fournier et al., 2002). In circumstances of mass migration and confinement, such as in refugee camps, there is an increased risk of parasite spread due to crowding, frequent person-to-person contact, and limited access to bathing facilities (Arnaud et al., 2016).

Body lice live in and lay eggs along clothing seams and are easily transmitted via close contact, shared clothing, or bedding. Clinical manifestations are typically limited to pruritus. Physical examination findings include erythematous papules, typically measuring 2 mm to 4 mm in diameter, from arthropod assault. If present, maculae cerulea, blue-grey macules that occur due to discoloration of the skin from the insect bites, can be a sign of lice infestation. Diagnosis can be made by identifying the louse or its eggs, which are visible to the naked eye or with a magnifying glass, in clothing seams (Fournier et al., 2002).

Although its symptoms are typically mild, the body louse is a vector for three life-threatening conditions: epidemic typhus, relapsing fever, and trench fever (also known as urban trench fever in reference to the recent resurgence among persons experiencing homelessness; Brouqui et al., 1996; Raoult and Roux, 1999). Although these conditions are rare in the general population, the risk of infection is particularly high when there is limited access to washing, such as in the scenarios of mass migration, crowded living, and confinement. Details of these conditions are summarized in Table 1 (Anstead, 2016; Badiaga and Brouqui, 2012; Barbour et al., 2015; Brouqui et al., 1996, 2005; Butler, 2017; Coates et al., 2020; Fournier et al., 2002; Hoch et al., 2015; LeBoit et al., 1989; Marra, 1995; Okulicz, 2019; Perine et al., 1992; Petri, 2019; Prieto-Granada et al., 2010; Warrell, 2019).

Vaccines for epidemic typhus used to be available and demonstrated moderate protection (Perine et al., 1992; Wisseman, 1972). However, low commercial interest and concerns regarding spontaneous reversion, combined with low overall incidence, have resulted in no commercially available vaccines today. Prevention of body-lice infestations is the crux of primary treatment of many body-lice-borne illnesses. Pyrethroid permethrin applied as a spray or dust to clothing and bedding has been reported to be highly effective at delousing clothing or bedding (Centers for Disease Control and Prevention [CDC], 2019; El-Bahnasawy et al., 2012); however, a recent randomized trial showed only a transient benefit from permethrin-treated underwear and an increase in permethrin-resistant body lice in those treated (Benkouiten et al., 2014). Other insect repellants, such as dichlorodiphenyltrichloroethane, malathion, and lindane, may be used, although potential resistance and toxicity is a concern (CDC, 2019).

Treatment of body lice can be challenging if good hygiene and thorough cleaning (or disposal) of infected clothing are not possible. Clothes should be washed at temperatures of  $\geq 130^{\circ}\text{F}$  and subsequently dried at high heat. Although challenging during mass migration and displacement, bathing and laundering at least once weekly and avoiding sharing of clothing, bedding, and towels are an integral part of treatment and prevention (CDC, 2019).

**Table 1**  
Serious body louse-borne illnesses.

Condition	Pathogen	Description	Relevance to displacement, mass migration, and confinement	Cutaneous manifestations	Therapy
Epidemic typhus	<i>Rickettsia prowazekii</i>	<ul style="list-style-type: none"> <li>■ Potentially lethal exanthematous disease</li> <li>■ High fever, intractable headache are common</li> <li>■ Can be infective up to 100 days</li> <li>■ Easily spread from sharing clothing or bedding</li> </ul>	<ul style="list-style-type: none"> <li>■ Typhus outbreaks detected across numerous refugee populations in Brundi, Rwanda, and the Congo</li> <li>■ Detection increased among the homeless population in Russia, Tunisia, and Algeria</li> <li>■ More common in the past, but studies show it is misdiagnosed or completely undiagnosed in places of poverty, famine, and war even today</li> </ul>	<ul style="list-style-type: none"> <li>■ Cutaneous eruption begins several days after onset of constitutional symptoms</li> <li>■ Physical examination: red morbilliform eruption on the trunk with centrifugal spreading to the extremities, sparing the face, palms, and soles</li> <li>■ Diagnosis made by clinical features, skin biopsy with fluorescent antibody staining, and/or laboratory testing (e.g., serology, PCR)</li> </ul>	<ul style="list-style-type: none"> <li>■ Doxycycline highly effective</li> <li>■ Symptoms typically improve after 48 hours of antibiotic treatment</li> </ul>
Trench fever	<i>Bartonella quintana</i>	<ul style="list-style-type: none"> <li>■ Earned its name during World War I, when it infected and caused significant morbidity and mortality among armies engaged in trench warfare</li> <li>■ Clinical features include paroxysmal fever, weakness, headache, severe back and shin pains</li> <li>■ Rarely can cause endocarditis, bacillary angiomatosis, and other serious cardiac and neurologic sequelae</li> </ul>	<ul style="list-style-type: none"> <li>■ Disproportionately affects persons experiencing homelessness, also known as urban trench fever</li> <li>■ Serologic positivity among impoverished populations shown to be significantly higher (8%–53%) compared with healthy controls (0%–2%)</li> </ul>	<ul style="list-style-type: none"> <li>■ Cutaneous eruption accompanies each febrile paroxysm</li> <li>■ Physical examination: 1) nonpruritic, blanching, erythematous macular rash on the trunk and proximal extremities; 2) bacillary angiomatosis that presents as red-to-purple papulonodules and hyperpigmented, hyperkeratotic indurated plaques that bleed when traumatized on the skin and mucosa</li> <li>■ Diagnosis: Definitive diagnosis is challenging due to difficulty isolating organism from culture; supported by skin biopsy, serology, and PCR</li> <li>■ Bacillary angiomatosis: Should be biopsied when present; histologic findings demonstrate circumscribed, lobular proliferation of capillaries lined with prominent large endothelial cells, neutrophilic infiltrates, and aggregates of bacillary bodies on Warthin-Starry silver stain</li> <li>■ Physical examination: Petechiae and ecchymoses (relating to bleeding disorders)</li> <li>■ JHR may exacerbate existing cutaneous lesions</li> <li>■ Diagnosis based on identification of spirochetes in blood smears, and PCR</li> </ul>	<ul style="list-style-type: none"> <li>■ Gentamicin (3 mg/kg/day for 2 weeks), followed by doxycycline (200 mg/day for 4 weeks)</li> <li>■ Erythromycin (500 mg 4 times daily) as first-line therapy, or doxycycline (100 mg 2 times daily) for &lt; 3 months in immunocompromised patients</li> </ul>
Relapsing fever	<i>Borrelia recurrentis</i>	<ul style="list-style-type: none"> <li>■ Characterized by recurrent fevers lasting 3–5 days, separated by intervals of apparent recovery</li> <li>■ Spirochetemia can cause blockage of small vessels, thrombocytopenia, and other serious hematologic complications</li> <li>■ JHR to an antibiotic treatment of spirochetal infections commonly occurs (37%–48%), characterized by shaking chills, rising temperature, and intensification of skin rashes</li> </ul>	<ul style="list-style-type: none"> <li>■ Today, principally a disease seen among refugees or in low-income countries and resource-poor settings</li> </ul>	<ul style="list-style-type: none"> <li>■ Physical examination: Petechiae and ecchymoses (relating to bleeding disorders)</li> <li>■ JHR may exacerbate existing cutaneous lesions</li> <li>■ Diagnosis based on identification of spirochetes in blood smears, and PCR</li> </ul>	<ul style="list-style-type: none"> <li>■ Single-dose intramuscular penicillin, oral tetracycline or erythromycin (500 mg), or doxycycline (100 mg) are highly effective</li> <li>■ Diagnosis and antibiotic treatment in vulnerable populations can be crucial, because antibiotic treatment can significantly reduce mortality from louse-borne relapsing fevers from 10%–60% to 2%–5%</li> <li>■ JHR, if present, typically self-resolves; observation for 4–6 hours is recommended after antibiotic treatment for possible reaction</li> </ul>

JHR, Jarisch-Herxheimer reaction; PCR, polymerase chain reaction

**Cutaneous leishmaniasis**

Leishmaniasis is a disease caused by the *Leishmania* parasite species that is transmitted by phlebotomine sandflies. Visceral leishmaniasis causes 20,000 to 30,000 deaths annually and is the second leading cause of parasite-related deaths after malaria (Kevric et al., 2015). Although rarely fatal, cutaneous leishmaniasis (CL) is one of the most common forms of leishmaniasis in humans, with an estimated 12 million people suffering from this condition

globally and 2 million new infections occurring every year (den Boer et al., 2011).

Previously confined to specific regions, various *Leishmania* species are spreading into new locations. Climate change is cited as a major determinant of this phenomenon (Steverding, 2017). Changes in temperature, humidity, and rainfall profoundly affect the distribution and survival of vectors and reservoirs, which is intimately linked to the geographic distribution of vector-borne illnesses (World Health Organization [WHO], 2020). For example,

sandflies can proliferate only when the ambient temperature stays >15.6 °C for at least 3 months of the year (Medlock et al., 2014). This suggests that global warming could significantly expand their habitat around the world (Kholoud et al., 2018). In Morocco, CL has emerged as a major public health threat in the last 20 years (Rhajaoui et al., 2007), and >40 novel cases have occurred in North America (primarily in Texas) where 59% of cases were acquired endemically (McIlwee et al., 2018).

In addition to global expansion, areas of unrest, migration, and refugee concentration have been the center of recent CL surges. In Lebanon, >1000 new CL cases were reported in 2013 alone compared with six total cases in the preceding decade; 96.6% occurred among displaced Syrian refugee populations (Alawieh et al., 2014). In Turkey, several hundred cases were reported in refugee settlements (Al-Salem et al., 2016). Outbreaks of CL have been well documented in Afghanistan after civil unrest, Iran after the devastating earthquakes in 2003, and the Sudanese refugee camps in Chad in 2007 (WHO, 2019).

CL has a wide range of manifestations based on the parasite virulence and host immune response. CL typically begins as pink papules that enlarge and develop into a nodule or plaque with central softening. Painless ulceration develops, with indurated borders and possible hyperkeratotic eschar or thick yellow fibrinous material. One of the cardinal features of CL is that the ulcers heal gradually, taking months to years, and result in atrophic, depressed, or keloidal scars. Ulcerated lesions are susceptible to secondary bacterial infections, which can further slow the healing process. Poor hygiene and exposure to various pathogens during mass migrations can put individuals at an even higher risk of persistent ulcers and large disfiguring scars (Saroufim et al., 2014). Social stigma associated with these scars has been shown to reinforce poverty in affected individuals (Bailey et al., 2017). Details of diagnosis and treatment for various types of CL can be found in the clinical practice guidelines by the Infectious Disease Society of America and the American Society of Tropical Medicine and Hygiene (Aronson et al., 2016).

### Cutaneous manifestations of HIV

Natural catastrophes can be especially detrimental to those living with HIV because access to care is intimately linked to survival. Unfortunately, regions with few resources and high HIV prevalence are often among those most frequently affected by natural disasters (ChildFund, 2013; Joint United Nations Programme on HIV and Acquired Immunodeficiency Syndrome [UNAIDS], 2018). When the highly destructive cyclones Ida and Kenneth hit the shores of Malawi, Mozambique, and Zimbabwe in 2019, >2 million people were directly affected. Among those were >100,000 HIV-infected patients whose access to critical treatments was abruptly terminated (UNAIDS, 2019).

Antiretroviral therapy (ART) is an important determinant of mortality and morbidity. HIV RNA levels quickly return to pre-treated levels within weeks of stopping ART, with breaks in ART potentially diminishing CD4 count gains. In turn, diminished CD4 counts can accelerate disease progression, serious complications (heart attacks, stroke, organ damage), and death (Harrigan et al., 1999; Kaufmann et al., 2011). A declining immune status, combined with unsanitary and confined living conditions, nutritional deficiency, and exposure to extreme weather and hazardous elements contribute to increased risk of developing serious secondary (e.g., systemic *S. aureus* infection, syphilis, disseminated streptococcal infection) and opportunistic (e.g., bacillary angiomatosis, toxoplasmosis, TB, candidiasis, herpes simplex and zoster) infections among patients with HIV (Schooley, 2016).

As their viral load increases, HIV-positive refugees and migrants pose a greater risk for transmission in confined communities

(Harrigan et al., 1999). Acute HIV infection manifests as a mononucleosis or flu-like syndrome, which develops within 2 to 4 weeks of the initial viral infection. A generalized skin eruption may occur, characterized by 5 mm to 10 mm, nonpruritic, well-circumscribed, round, pink-to-red maculopapules, most commonly on the upper thorax, neck, and face, but also on the extremities, scalp, soles, and palms (Lapins et al., 1997).

Neoplasms in HIV-positive patients may behave differently than in noninfected persons. For refugees and migrants living with HIV, skin cancer surveillance is likely difficult but critical. Patients with HIV have an overall two-fold increase in the risk for skin cancers, which on average occur at an earlier age than in the general population (Crum-Cianflone et al., 2009; Silverberg et al., 2013).

Kaposi sarcoma (KS) is a vascular tumor associated with human herpesvirus-8 infection that is most frequently described in HIV-infected and other immunocompromised patients (Mesri et al., 2010). KS typically begins as light brown or pink papules or patches that later coalesce into large, darker violet plaques or nodules with ulceration on the trunk, extremities, face, oral mucosa, and genitalia, with associated lymphedema (Buonaguro et al., 2003). ART has significantly reduced the incidence of KS in patients with HIV so that it is no longer the most common skin cancer in this group, but the relative risk still remains higher than in the general population, even after an HIV-positive patient's immune system is restored (Biggar et al., 2007). KS continues to be among the most common causes of morbidity and mortality in people living with HIV worldwide (Crum-Cianflone et al., 2009).

Adverse cutaneous drug reactions (ACDRs) are also far more common among HIV-positive patients, making up 8% of all HIV-associated dermatologic presentations (Coopman et al., 1993). Displaced and migrant HIV-positive patients without access to ART are at an increased risk for ACDRs; their prevalence is correlated with low immunity and low CD4 cell counts (Smith et al., 1997). Presentations are typically mild. Morbilliform eruptions make up 95% of all cases and other milder conditions, such as urticarial rash, erythema multiforme, fixed drug eruption, and lichenoid drug eruptions, can occur (Hoosen et al., 2019). Although the incidence of severe drug reactions, such as Steven-Johnson syndrome and toxic epidermal necrolysis, are higher among patients with HIV, they are still rare and make up only 0.5% of all ACDR cases (Yunihastuti et al., 2014). A history of ACDR should be explored prior to reintroducing ART or other therapies in HIV-positive migrants and refugees because ACDR has been reported in numerous antimicrobial agents, prophylactic agents, antituberculous therapy, and ART agents (Yunihastuti et al., 2014). Hoosen et al. (2019) described various ACDRs in HIV/AIDS in detail.

### Cutaneous tuberculosis

Declared a global health emergency by the WHO, TB remains a profound public health threat in most parts of the world. With >10 million new cases and 1.3 million deaths annually, over one third of the world's population is estimated to be infected with TB (Furin et al., 2019). Although close to 90% of those infected remain asymptomatic and noninfectious, the risk of reactivation remains throughout one's lifetime (Gideon and Flynn, 2011).

Caused by *M. tuberculosis*, TB is a highly transmissible disease, and treatment requires significant infrastructural support and environmental control, which can be disrupted and altered during climate disasters (Abarca et al., 2013). Natural disasters abruptly hamper vaccination efforts (e.g., Bacille Calmette-Guerin), TB surveillance, antituberculous therapies, and other critical elements of TB prevention that minimize prolonged infectivity, drug resistance, relapse, and death (Gebreweld et al., 2018). Respiratory infection control, such as distancing, ventilation, hand hygiene,

**Table 2**  
Cutaneous TB.

Treatment: Systemic anti-TB therapy is the mainstay of cutaneous TB treatment. Treatment should be continued for at least 2 months after complete resolution of skin lesions.

Disease	Description	At-risk population	Cutaneous manifestations	Complications and importance of treatment
Exogenous inoculation (inoculation of organism into the skin)				
Primary inoculation TB	<ul style="list-style-type: none"> <li>■ Occurs in nonsensitized individuals</li> <li>■ Rare form of cutaneous TB</li> <li>■ Direct entry of organism into the skin or mucosa causing an infection</li> </ul>	<ul style="list-style-type: none"> <li>■ Primarily in children in endemic areas of TB</li> <li>■ Most commonly affects sites of minor trauma where skin barrier is compromised</li> </ul>	<ul style="list-style-type: none"> <li>■ Typically &lt;1 cm red-brown papule or nodule on face and extremities, progressing to shallow undermined ulcer formation with granulomatous base</li> <li>■ Painless regional lymphadenopathy progressing to draining sinuses</li> <li>■ Erythema nodosum, lupus vulgaris, scrofuloderma may copresent</li> </ul>	<ul style="list-style-type: none"> <li>■ Cutaneous lesions can persist up to 1 year if left untreated</li> <li>■ Leaves scar after resolution</li> <li>■ Patient becomes sensitized to TB</li> </ul>
TB verrucosa cutis	<ul style="list-style-type: none"> <li>■ Occurs in previously sensitized individuals</li> <li>■ More common form of cutaneous TB</li> <li>■ Direct entry of organism into the skin or mucosa</li> </ul>	<ul style="list-style-type: none"> <li>■ Children exposed to contaminated areas</li> <li>■ Exposure to contaminated environment may increase risk</li> <li>■ Occupational exposure to mycobacteria (e.g., pathologist, laboratory technicians, farmers) increases risk</li> </ul>	<ul style="list-style-type: none"> <li>■ Solitary 1–5 cm red-brown or violaceous indurated plaques with warty appearance</li> <li>■ Potential fissure formation leading to purulent drainage</li> <li>■ Acral extremities (fingers, dorsum of the hands), ankle, or buttocks most commonly affected</li> </ul>	<ul style="list-style-type: none"> <li>■ Elephantiasis and lymphostasis may be seen</li> <li>■ Can persist for years if left untreated</li> </ul>
Contiguous spread (transmission to the skin from adjacent structures)				
Scrofuloderma (TB colliquative cutis)	<ul style="list-style-type: none"> <li>■ Direct extension of infection from deep structure (e.g., lymph node, bone, joint, epididymis) into overlying skin</li> </ul>	<ul style="list-style-type: none"> <li>■ Most common in children, adolescents, and older adults</li> </ul>	<ul style="list-style-type: none"> <li>■ Firm subcutaneous red-brown nodules progressing to ulcer and sinus tract formation that drain clear, purulent, or caseous material</li> <li>■ Nodules overlying TB infection in the neck, axillae, and groin</li> <li>■ Cervical lymph nodes most commonly affected</li> <li>■ Linear distribution of nodules overlying chain of lymph nodes underneath</li> </ul>	<ul style="list-style-type: none"> <li>■ Lesions take years to completely resolve if untreated. Leaves scar tissue</li> <li>■ Lupus vulgaris may develop close to scrofuloderma lesions</li> </ul>
TB cutis orificialis	<ul style="list-style-type: none"> <li>■ Orifical TB is rare</li> <li>■ Autoinoculation of mucocutaneous surfaces close to orifices near draining sites or sites of visceral infection</li> </ul>	<ul style="list-style-type: none"> <li>■ Most commonly among older adults</li> </ul>	<ul style="list-style-type: none"> <li>■ Single red-yellow nodule rapidly progressing into painful, circular, friable, and irregularly shaped ulcer</li> <li>■ May have punched-out appearance</li> </ul>	<ul style="list-style-type: none"> <li>■ Significant internal organ involvement is common; thus, vigilant surveillance of underlying TB infection is needed</li> <li>■ Does not resolve spontaneously; treatment necessary because could lead to fatal military TB</li> <li>■ Difficult to treat and can progress through treatment</li> <li>■ Presence of TB cutis orificialis could indicate a poor overall prognosis</li> </ul>
Lupus vulgaris	<ul style="list-style-type: none"> <li>■ Chronic and progressive form of cutaneous TB</li> <li>■ Due to reactivation of TB in patients with moderate-to-high immunity against pathogen</li> <li>■ Spread by direct extension from underlying site of infection or by hematogenous spread</li> </ul>	<ul style="list-style-type: none"> <li>■ 2–3 times higher prevalence in women</li> <li>■ People in Europe, parts of India, and tropical regions are most commonly affected</li> <li>■ Most common type of cutaneous TB in Europe and Hong Kong</li> </ul>	<ul style="list-style-type: none"> <li>■ Variable cutaneous presentation</li> <li>■ Red-brown papules coalescing into asymptomatic plaque with central clearing and atrophy, most commonly on the head and neck; lower extremities and buttocks involvement more common in the tropics</li> <li>■ Plaques may have serpiginous or verrucous borders</li> </ul>	<ul style="list-style-type: none"> <li>■ Lupus vulgaris could be rare complication of BCG vaccination</li> <li>■ Can develop after scrofuloderma</li> <li>■ Does not resolve spontaneously; treatment necessary to prevent significant disfigurement from growing plaques, resulting in ulceration and destruction of underlying tissues (particularly in the nose, ears, and lips)</li> </ul>

**Table 2** (continued)

Treatment: Systemic anti-TB therapy is the mainstay of cutaneous TB treatment. Treatment should be continued for at least 2 months after complete resolution of skin lesions.				
Disease	Description	At-risk population	Cutaneous manifestations	Complications and importance of treatment
			<ul style="list-style-type: none"> <li>■ Other variable forms include hypertrophic, ulcerative, vegetative forms</li> <li>■ Differential location by region: head and neck in the western world; on lower extremities and buttocks in tropical and subtropical regions</li> </ul>	
Hematogenous spread (transmission via bloodstream) Metastatic TB abscesses (TB gummas)	Occurs due to hematogenous spread of organism from primary site of infection to subcutaneous tissue during state of compromised immunity	<ul style="list-style-type: none"> <li>■ Children malnourished or of low socioeconomic status</li> <li>■ Immunosuppressed adults (uncommon in immunocompetent individuals)</li> </ul>	<ul style="list-style-type: none"> <li>■ Single or multiple nontender, fluctuant, subcutaneous nodules that progress to ulcers and draining sinuses typically in the extremities</li> </ul>	<ul style="list-style-type: none"> <li>■ May spontaneously resolve without treatment</li> <li>■ May persist for several years without treatment in immunocompromised patients</li> <li>■ Negative prognostic factor when found in immunocompromised or malnourished people</li> </ul>
Acute miliary TB (TB cutis miliaris disseminata)	Rare form of cutaneous TB from hematogenous spread from primary infection focus, such as the lung	<ul style="list-style-type: none"> <li>■ Infants</li> <li>■ Patients with impaired cell-mediated immunity (e.g., AIDS)</li> </ul>	<ul style="list-style-type: none"> <li>■ Cutaneous presentations uncommon; appear as tiny papules or vesiculopapules; rarely, macular, pustular, or purpuric lesions, indurated ulcerating plaques, and subcutaneous abscesses can occur</li> </ul>	<ul style="list-style-type: none"> <li>■ Miliary TB is fatal if untreated</li> <li>■ Cutaneous lesions typically resolve in 4 weeks of treatment, leaving hypopigmented depressed scars</li> </ul>
Lupus vulgaris	See contiguous spread			
Hypersensitivity reaction Tuberculids	(non-infectious etiology) Tuberculids are cutaneous hypersensitivity eruptions to <i>M. tuberculosis</i> in patients with moderate or high levels of immunity against the pathogen. Bacilli are typically not detectable in tuberculid lesions. There are three types of tuberculids			
Papulonecrotic tuberculid	<ul style="list-style-type: none"> <li>■ Chronic, recurrent, and symmetric eruption of necrotizing skin papules in crops</li> <li>■ Most common form of tuberculid</li> </ul>	<ul style="list-style-type: none"> <li>■ Children and young adults</li> </ul>	<ul style="list-style-type: none"> <li>■ Symmetric, asymptomatic crops of dusky red pea-sized papules with crusting and ulceration on extensor extremities; pustules may be present</li> <li>■ Lymphadenitis may be present</li> <li>■ Presence of active lesion adjacent to scarring is diagnostic clue</li> </ul>	<ul style="list-style-type: none"> <li>■ May spontaneously resolve after several weeks; responds dramatically to anti-TB therapy</li> <li>■ Lesions spontaneously involute, leaving many pitted scars</li> <li>■ Without treatment, could persist for years</li> <li>-Chronic recurrent condition</li> </ul>
Lichen scrofulosorum (TB cutis lichenoides)	<ul style="list-style-type: none"> <li>■ Tuberculid characterized by small papular lesions with or without active TB</li> <li>■ May be easily missed due to similar appearances as other dermatoses</li> <li>■ Rarer</li> </ul>	<ul style="list-style-type: none"> <li>■ Children and young adults</li> <li>■ Most commonly associated chronic TB of lymph node and bones</li> </ul>	<ul style="list-style-type: none"> <li>■ Numerous asymptomatic, 1–5mm perifollicular grayish-white lichenoid papules in groups on the trunk, papules on the trunk</li> </ul>	<ul style="list-style-type: none"> <li>■ Resolves spontaneously after several months to years without scarring</li> <li>■ With anti-TB treatment, complete resolution within weeks to months</li> </ul>
Erythema induratum of Bazin	<ul style="list-style-type: none"> <li>■ Granulomatous lobular panniculitis of lower extremities</li> <li>■ Common</li> </ul>	<ul style="list-style-type: none"> <li>■ Predilection for women (80%–90% of cases) with age peaks in early adolescence and around menopause</li> </ul>	<ul style="list-style-type: none"> <li>Bilateral, symmetric, erythrocyanotic nodules on posterior lower extremities, progressing slowly to ulceration and central necrosis with irregular deep lesions and undermined borders</li> </ul>	<ul style="list-style-type: none"> <li>■ Spontaneously resolves over several months leaving atrophic hyperpigmented scars</li> <li>■ Several lesions at various stages are seen, leaving scars and hyperpigmentation</li> <li>■ Chronic condition with frequent recurrence</li> </ul>

(continued on next page)

**Table 2** (continued)

Treatment: Systemic anti-TB therapy is the mainstay of cutaneous TB treatment. Treatment should be continued for at least 2 months after complete resolution of skin lesions.

Disease	Description	At-risk population	Cutaneous manifestations	Complications and importance of treatment
Others				<ul style="list-style-type: none"> <li>■ Anti-TB therapy, potassium iodide, nonsteroidal anti-inflammatory drugs, dapsone, colchicine, glucocorticoids have been useful</li> </ul>
BCG vaccination reactions	<ul style="list-style-type: none"> <li>■ BCG is only vaccine used against TB today containing live attenuated <i>M. tuberculosis</i> strain</li> <li>■ Rarely given in United States, but still commonly used in low- and middle-income countries</li> <li>■ Dermatologic complications can occur</li> </ul>	-	<ul style="list-style-type: none"> <li>■ May develop red, tender, indurated papule at injection site with possible crusting and draining 2–6 weeks after injection</li> <li>■ Other local tissue reactions, ulceration, abscess formation, scrofuloderma, lupus vulgaris, erythema induratum of Bazin, papulonecrotic tuberculid, lichen scrofulosorum-like lesions may occur</li> </ul>	<ul style="list-style-type: none"> <li>■ Injection site reaction spontaneously heals in several weeks, leaving superficial scar</li> <li>■ More serious, but rare complications include anaphylactic reactions</li> </ul>

BCG, Bacille Calmette-Guerin; TB, tuberculosis.

and mask or other personal protective equipment use, are necessary but difficult during catastrophes and crowded living (CDC, 2020). After the Great East Japan Earthquake in 2011, 20% of evacuees living in shelters tested positive for TB, and adherence rates (19%) to latent-TB treatments were low after Hurricane Katrina (Kanamori et al., 2013). TB reactivation risk is amplified in the setting of malnutrition and low immunity (Semba et al., 2010); however, the lack of health care personnel, equipment, and funds in refugee camps and migrant communities during natural disasters and times of crises make detection concomitantly more challenging (WHO, 2015).

Cutaneous TB (CTB) is relatively uncommon, occurring in 1% to 2% of infected patients and representing only 2% of extrapulmonary TB (van Zyl et al., 2015). Similar to other forms of TB, a resurgence of CTB has been noted in areas where HIV and multidrug-resistant TB are more prevalent (CDC, 2016). Diagnosis is often delayed because CTB is rarely included in the differential diagnosis of atypical or nonhealing skin lesions (Frankel et al., 2009). Various manifestations of CTB are summarized in Table 2. (Barbagallo et al., 2002; Bellet and Prose, 2005; Choi et al., 2009; Dias et al., 2014; Fariña et al., 1995; Frankel et al., 2009; Handog et al., 2008; Jordaan et al., 1996; Machan et al., 2018; MacGregor, 1995; Marcoval et al., 1992; Mascaró and Baselga, 2008; Molpariya and Ramesh, 2017; Santos et al., 2014; Sehgal, 1994; Sharma et al., 2005; WHO, 2012; Wilson-Jones and Winkelmann, 1986; Yates and Ormerod, 1997).

**Conclusion**

Dermatologic manifestations of climate change are myriad; however, the proliferation of infectious and communicable diseases is particularly troubling because they typically affect poor, vulnerable, and marginalized patients most severely. Major climate change propagates the mass migration and confinement of migrants in shelters, where the lack of proper hygiene and medical care can lead to serious conditions with cutaneous manifestations. Preventing overcrowding, installing public health measures, and re-establishing access to care are essential, but more importantly, addressing one of the primary determinants of these mass migra-

tions by mitigating the anthropogenic effects of climate change would serve to improve outcomes for migrants and refugees the world over.

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