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Review

Management guidelines for pregnant health care workers exposed to infectious dermatoses

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ABSTRACT

Exanthematous diseases are frequently of infectious origin, posing risks, especially for pregnant health care workers (HCWs) who treat them. The shift from cell-mediated (Th1 cytokine profile) to humoral (Th2 cytokine profile) immunity during pregnancy can influence the mother's susceptibility to infection and lead to complications for both mother and fetus. The potential for vertical transmission must be considered when evaluating the risks for pregnant HCWs treating infected patients because fetal infection can often have devastating consequences. Given the high proportion of women of childbearing age among HCWs, the pregnancy-related risks of exposure to infectious diseases are an important topic in both patient care and occupational health. Contagious patients with cutaneous manifestations often present to dermatology or pediatric clinics, where female providers are particularly prevalent; a growing number of these physicians are female. Unfortunately, the risks of infection for pregnant HCWs are not well defined. To our knowledge, there is limited guidance on safe practices for pregnant HCWs who encounter infectious dermatologic diseases. In this article, we review several infectious exanthems, their transmissibility to pregnant women, the likelihood of vertical transmission, and the potential consequences of infection for the mother and fetus. Additionally, we discuss recommendations with respect to avoidance, contact, and respiratory precautions, as well as the need for treatment after exposure.

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Introduction

It is estimated that 48.9% of practicing dermatologists are female (Association of American Medical Colleges, 2017). Given that 48.8% of physicians under the age of 35 years are female (American Medical Association, 2015), a significant portion of both female trainees and attending physicians are of childbearing age. In particular, dermatologists, pediatricians, and other health care workers (HCWs) in these offices routinely care for patients who present with infections with cutaneous manifestations. For pregnant HCWs, balancing patient care responsibilities and occupational safety can be challenging, especially when the risk of transmission in the clinical setting is unknown.

To our knowledge, there is no comprehensive review of the literature that specifically identifies the risk of transmission of common exanthematous diseases to pregnant HCWs. This review identifies various infectious exanthems to which pregnant HCWs may be exposed and summarizes current available evidence regarding risk of transmission. Specifically, we discuss parvovirus B19 (PVB19), hand, foot and mouth disease (HFMD), mycoplasma-induced rash and mucositis (MIRM), measles, herpes simplex virus (HSV), varicella-zoster virus (VZV), and pityriasis rosea (PR). We also provide guidelines for each disease so pregnant HCWs and HCWs of reproductive potential can appropriately minimize risk and pursue work-up and treatment, if necessary, after exposure. Finally, given the ongoing global coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), we also summarize available safety guidelines for pregnant HCWs who are working during this time.

Parvovirus

A wide range of clinical manifestations have been associated with PVB19 infection, including erythema infectiosum, arthropathy, and aplastic crisis. Erythema infectiosum is the most common dermatologic manifestation of PVB19, presenting in children between the ages of 5 and 14 years after a prodrome. The classic presentation involves a facial rash with a slapped-cheek appearance, followed by a morbilliform eruption on the extremities and trunk 1 to 4 days later. Once the rash appears, patients are no longer contagious (Servey et al., 2007). As such, although providers are at risk of infection during the PVB19 prodromal phase, they are likely protected if patients present with a rash.

The disease course itself is self-limiting, but PVB19 infection during pregnancy has been attributed to several adverse fetal outcomes, including intrauterine fetal demise, thrombocytopenia, and hydrops fetalis. Transmission occurs primarily via exposure to droplets and fomites but can also occur via vertical transmission. The rate of baseline immunity to PVB19 in pregnant populations ranges from 35% to 65% (Gillespie et al., 1990; Gratacós et al., 1995; Valeur-Jensen et al., 1999). The incidence of acute PVB19 infection in susceptible pregnant women is reported to be 1% to 2%, with an estimated vertical transmission rate of approximately 25% to 35% (Gratacós et al., 1995; Neu et al., 2015). Risks for childcare workers, including school teachers and daycare center employees, are well documented in the literature (Riipinen et al., 2014). A population-based cohort study in Denmark of >30,000 pregnant women found that working as a nursery school teacher and having more children in the household were among the greatest risk factors associated with acquiring parvovirus infection (Valeur-Jensen et al., 1999).

Data on the risk of transmission to HCWs, however, are conflicting (Adler et al., 1993). Various case reports and case series (Harrison and Jones, 1995; Lara-Medrano et al., 2016; Sungkate et al., 2017) have demonstrated risk of transmission of parvovirus infection to HCWs after exposure to infected patients. One single-center study at the Children's Hospital of Philadelphia found an elevated risk of infection between exposed and unexposed staff (Bell et al., 1989). However, a cohort study of 87 HCWs exposed to two patients with PVB19-induced aplastic crisis found no significant increase in PVB19-specific immunoglobulin (Ig) M and IgG antibodies when compared with unexposed HCWs at the same facility (Ray et al., 1997).

Although the risk of transmission to HCWs has not been definitively identified, preventing the transmission of PVB19 infection is important because infection can lead to adverse pregnancy outcomes. PVB19 infection carries a 9% excess risk of miscarriage within the first 20 weeks of gestation and a 2.9% risk of fetal hydrops between weeks 9 and 20 (Miller et al., 1998).

Management recommendations

Pregnant HCWs should not be part of the care team for patients with suspected PVB19 infection, if possible. If exposure is suspected, risk assessment should consider the presence of an ongoing outbreak as well as the extent of contact that the HCW had with exposed patients. Droplet precautions should be strictly followed when caring for patients with PVB19. Refer to Table 1 for the different types of infection control and prevention precautions. If a pregnant HCW is exposed to a known or suspected parvovirus case, she should undergo PVB19 testing for IgM and IgG (Crowcroft et al., 1999; Katta 2002; Kho et al., 2008; Lamont et al., 2011). If IgM positive, pregnant HCWs at <21 weeks of gestation should undergo serial ultrasound examinations scheduled per obstetrician recommendation to assess for development of fetal hydrops. Maternal intravenous immunoglobulin (IVIG) administration is not recommended. Refer to Table 2 for a summary of infection risk, complications, prevention, and management guidelines.

Hand, foot, and mouth disease

HFMD is a highly contagious viral infection typically caused by coxsackievirus A16 and enterovirus 71. The infection, which is primarily transmitted via respiratory droplets, contact with blisters, or contact with feces, most commonly affects children under the age of 5 years. HFMD is classically characterized by a macular, morbilliform, or vesicular rash that affects the hands, feet, and oral mucosa. As one of the most common pediatric exanthems, HFMD is routinely seen by pediatric and dermatology HCWs, presenting a potential concern for occupational exposure.

Although outbreaks of HFMD have been regularly reported worldwide in children, symptomatic infections in adults are less common (Chang et al., 2004). Individual cases of adult infection have been reported in the literature (Murase and Akiyama, 2018; Stewart et al., 2013). The coxsackievirus A6 (CVA6) serotype has been linked to several HFMD outbreaks worldwide, affecting both adults and children (Kimmis et al., 2018; Ramirez-Fort et al., 2014). HFMD due to CVA6 differs in presentation from classic HFMD. Unlike in typical HFMD, adults with CVA6 HFMD are more likely to develop vesicular eruptions involving the dorsal hands and feet, as well as the face (Horsten et al., 2018). The lesions may also appear more purpuric than typical HFMD and can mimic secondary syphilis. Later in the disease process, the rash can desquamate and mimic fungal infection (Ramirez-Fort et al., 2014). Other features include widespread vesiculobullous and erosive lesions extending beyond the palms and soles, an eczema herpeticum-like eruption termed "eczema coxsackium," and an eruption similar to Gianotti-Crosti in children (Mathes et al., 2013). There can also be occasional sparing of the oral mucosa (Second et al., 2017). Out-

Table 1
Infection control and prevention precautions.

	Standard precautions	Isolation precautions		
		Droplet precautions	Airborne precautions	Contact precautions
Protection measures	Hand hygiene	Source control (place mask on patient)	Source control (place mask on patient)	Use of PPE, including gloves and gown
	Use of PPE such as gloves, eyewear, and surgical masks during procedures	Place patient in an airborne infection isolation room (or private room if airborne infection isolation room is unavailable)	Place patient in an airborne infection isolation room (or private room if airborne infection isolation room is unavailable)	Place patient in private room if possible
	Proper handling and disposal of sharps	Restrict susceptible HCWs from entering patient room	Restrict susceptible HCWs from entering the room Use PPE such as fit-tested N95 mask	Limit transport of patient
	Proper cough etiquette	Use PPE such as surgical face mask	Limit transport of patient	Use disposable or dedicated patient-care equipment
	Proper disinfection of equipment	Limit transport of patient	Immunize susceptible HCWs as soon as possible following unprotected contact if indicated	Prioritize cleaning/disinfection of patient room
				Use proper hand washing prior to leaving patient room

HCW, health care worker; PPE, personal protective equipment.

breaks of HFMD in adults that have been reported in the literature have typically occurred in adults after exposure to children with HFMD (Centers for Disease Control and Prevention [CDC] Morbidity and Mortality Weekly Report, 2012) or among college students (Buttery et al., 2015) and military trainees (Banta et al., 2016).

HFMD during pregnancy has been rarely reported in the literature and is largely limited to case reports (Chow et al., 2000; Deeb et al., 2019; Ogilvie and Tearne, 1980), with no reports discussing pregnant HCWs specifically. One report identifies fetal demise secondary to maternal coxsackievirus A16 infection with confirmed massive placental perivillous fibrinoid deposition (Heller et al., 2016). Another found no evidence to suggest that HFMD affected pregnancy course or newborn development (Second et al., 2017). A retrospective observational study in Italy of 128 pregnant patients with clinically suspected HFMD or documented exposure found no conclusive evidence that HFMD affected fetal or neonatal outcomes (Giachè et al., 2019). The CDC also reports no clear evidence that non-polio enterovirus infection during pregnancy increases the risk of severe complications, including miscarriage, stillbirth, or congenital defects (CDC, 2019a,b).

Management recommendations

Although the rate of HFMD is high among children, transmission to adults is less likely and often confers an asymptomatic or milder course. The literature regarding HFMD outcomes in pregnant women is limited. As such, we recommend proper and consistent hand hygiene and strict droplet and contact precautions for any pregnant HCW who participates in the care of a suspected HFMD case. It is also prudent to inform the HCW's obstetric provider for close monitoring (Ventarola et al., 2015). If an HFMD case is severe and requires hospitalization, we recommend isolation of the patient. If possible, we recommend having another provider assume care for patients with HFMD in these cases.

Mycoplasma-induced rash and mucositis

Mycoplasma infections are associated with various adverse outcomes in pregnancy. Although the incidence of *Mycoplasma pneumoniae* infection during pregnancy is unknown (Matsuda et al., 2017), pneumonia during pregnancy is well-associated with preterm labor and low birth weight (Chen et al., 2012).

MIRM refers to *Mycoplasma pneumoniae*–associated mucocutaneous disease with prominent mucositis and varying degrees of cutaneous involvement (Canavan et al., 2015). Classically, MIRM presents as severe conjunctivitis and blepharitis, severe oral mucositis with hemorrhagic crusting, and sparse vesiculobullous eruption in children and adolescents with a 2:1 male-to-female predominance (Canavan et al., 2015). To our knowledge, there are no reports in the literature of MIRM during pregnancy. Care for patients with MIRM involves supportive care, including fluids, analgesia, and ophthalmology and urology evaluation (Canavan et al., 2015).

Management recommendations

To our knowledge, MIRM has not been reported in a pregnant patient or HCW. We recommend dermatology consultation if an HCW is symptomatic after exposure to patients with mycoplasma manifesting as MIRM, with close monitoring of symptom resolution. Treatment should be similar to that for a nonpregnant patient with MIRM, which includes evaluation and monitoring by a physician, antibiotics, systemic corticosteroids, or (rarely) IVIG administration.

Measles

The global incidence of measles has climbed in recent years. Sizeable outbreaks continue to occur around the world, largely because of decreased vaccination rates. Although skin manifestations of measles are nondiagnostic, it is increasingly important for HCWs to be able to recognize the disease.

The clinical manifestations of measles virus infection classically begin with a prodrome characterized by fever, malaise, cough, coryza, and conjunctivitis. Koplik spots may appear during the prodromal phase. An erythematous, morbilliform exanthem appears approximately 3 to 5 days after the onset of symptoms, with cranial to caudal progression. The patient is considered contagious 4 days before and after the appearance of the rash. Notably, exanthem may be absent in immunocompromised patients and pregnant women, making measles more difficult to recognize.

Table 2
Summary of infection risk, transmission, adverse outcomes, prevention, and treatment in PVB19, HFMD, MIRM, measles, HSV, VZV, and PR for pregnant HCWs.

Pathogen/disease	Mode of transmission	Incidence in pregnant women	Rate of vertical transmission	Risk of adverse fetal/neonatal outcomes	Infection control precautions	Postexposure treatment
Parvovirus B19 (PVB19)	Respiratory secretions, saliva droplets, fomites, transplacental, blood products	1–2%	25–35%	9% excess risk of miscarriage in first 20 weeks 2.9% risk of fetal hydrops between weeks 9 and 20	Droplet precautions	PVB19 testing for IgM and IgG. If IgM positive and <21 weeks of gestation, pregnant HCW should undergo serial ultrasound examinations
Hand, foot, and mouth disease (HFMD)	Respiratory secretions, saliva droplets, contact with blister fluid, fomites, or feces	Unknown	Unknown	Inconclusive; there is some concern regarding perinatal transmission to newborns	Droplet and contact precautions	Adequate hydration and analgesia Inform obstetric provider; close monitoring
Mycoplasma-induced rash and mucositis (MIRM)	Respiratory secretions, saliva droplets	Unknown	Unknown	Unknown	Droplet precautions	Dermatology consultation if symptomatic
Measles	Saliva droplets, respiratory secretions, fomites	Unknown (rare)	Unknown; (horizontal transmission rate up to 90%)	Low birth weight, intrauterine fetal demise, prematurity Maternal complications: diarrhea (60%), pneumonia (40%), encephalitis (5%), death (12%)	Airborne precautions	Nonimmune pregnant women should receive intravenous immunoglobulin treatment within 6 days of exposure. Any exposed HCW without evidence of immunity should be excluded from the healthcare setting from the fifth through 21st days after exposure
Herpes simplex virus (HSV)	Perinatal contact with lesions, saliva, mucosal contact	At least 2% in susceptible pregnant women; prevalence of genital HSV-1 and HSV-2 in pregnant women is 25–65% (including subclinical genital infection)	Neonatal herpes develops in less than 1% of infants delivered vaginally to women with HSV-2 shedding at term; 50–80% of cases of neonatal HSV result from women who acquire genital HSV-1 or HSV-2 infection near term	Congenital HSV (sepsis, microcephaly, hydrocephalus, chorioretinitis), vesicular lesions, central nervous system involvement (lethargy, poor feeding, seizures, developmental delay, epilepsy, blindness, and cognitive disabilities)	Contact precautions if localized Airborne precautions if disseminated	Occupational exposure to HSV is unlikely if appropriate precautions are followed by HCW
Primary varicella zoster virus (VZV) infection	Vertical transmission (in utero, perinatal, postnatal), saliva droplets, respiratory secretions, and contact with vesicles	0.7–3 per 1000 pregnancies	8% in PCR-confirmed cases before 24 weeks	Intrauterine growth restriction (23%), low birth weight (nearly universal), VZV pneumonia (2.5%), Congenital varicella syndrome (0.91% in first 20 weeks of pregnancy and 2% at 13–20 weeks of gestation)	Airborne precautions	Susceptible (seronegative) pregnant HCWs exposed to VZV should receive varicella-zoster immune globulin (e.g., VariZIG) as soon as possible, ideally within 96 hours but up to 10 days after exposure. Susceptibility should be confirmed by serology prior to administration if possible. Careful monitoring for signs of infection despite passive immunization is essential. Nonimmune HCWs should be furloughed during days 8–28 after exposure and should be placed on sick leave until symptoms resolve. Fetal and maternal monitoring is crucial
Pityriasis rosea (PR)	Unclear etiology; associated with HHV-6 and HHV-7	Overall incidence is 0.5–2%. When PR occurs in women ages 17–48 years, 18% of cases occur during pregnancy	Unknown; insufficient evidence	Increased risk of miscarriage in first 15 weeks of gestation	Standard precautions	Close monitoring if PR occurs within first 15–20 weeks of gestation or if mother experiences constitutional symptoms or an unusually diffuse, prolonged rash. In these cases, consider acyclovir 400 mg TID for 7 days, which has been shown to hasten the resolution of PR lesions and relieve pruritus

HCW, health care worker; PCR, polymerase chain reaction; TID, thrice daily.

Table 3
Vaccination recommendations for healthcare workers (Adapted from CDC Advisory Committee on Immunization Practices, 2011).

Vaccine	Criteria for vaccination	Vaccination regimen
Hepatitis B (HepB)	No documented completion of previous HepB vaccine series	Three doses: second dose 1 month after first dose; third dose 5 months after second dose
	OR	AND
	No serologic evidence of immunity	Serologic testing after completion
Influenza	Recommended annually for all	Single dose annually
Measles, mumps, rubella (MMR)	Born in 1957 or later AND no past immunization or no serologic evidence of immunity	If not immune to measles or mumps, two doses 28 days apart are required
	(Although birth before 1957 is considered evidence of immunity, consider vaccinating these HCWs if no serologic evidence of immunity is available)	If not immune to rubella only, a single dose is required
Varicella	No history of infection	Two doses 4 weeks apart
	OR	
	No past immunization	
	OR	
	No serologic evidence of immunity	
Tetanus, diphtheria, pertussis (Tdap)	No past receipt of Tdap	Single dose, regardless of past Td vaccine
	All personnel	Boosters every 10 years
	Pregnant HCWs	Tdap dose during each pregnancy
Meningococcal	HCWs with routine exposure to *Neisseria meningitidis*	Single dose

Measles during pregnancy has been associated with an increased risk of adverse maternal, fetal, and neonatal outcomes. One retrospective cohort analysis of 55 pregnant women with measles in Namibia showed increased risks for low birth weight, spontaneous abortion, intrauterine fetal death, and maternal death when compared with pregnancies without measles (Ogbuanu et al., 2014). In this study, 71% of the women developed measles-related complications, including diarrhea (60%), pneumonia (40%), and encephalitis (5%). Of the pregnancies with known outcomes, 60% had at least one adverse outcome, including maternal death in 12% of cases.

Other studies comparing women with and without measles during pregnancy have shown an increased frequency of prematurity, increased likelihood of neonatal intensive care unit admission, and longer intensive care unit stays among neonates born to mothers with gestational measles (Ali and Albar, 1997; Siegel and Fuerst, 1966). The rate of congenital defects does not appear to be higher among neonates born to mothers with measles than to uninfected mothers (Siegel, 1973; Ali and Albar, 1997). However, congenital measles can occur, with severity ranging from mild to fatal (Gershon, 2006). Congenital measles has been reported among neonates born to women who had measles within 10 days of delivery (Charlier et al., 2015). Measles is highly contagious, with up to 90% of susceptible individuals becoming infected upon exposure (McLean et al., 2013). HCWs are at a higher risk of being exposed to, and subsequently developing, measles than the general adult population (Shefer et al., 2011).

Management recommendations

All HCWs should provide evidence of immunity to measles prior to employment, and nonpregnant HCWs should receive the measles, mumps, and rubella (MMR) vaccine in the absence of such evidence (Bolyard et al., 1998; McLean et al., 2013; Siegel et al., 2007). Women should avoid becoming pregnant for 4 weeks after vaccination (McLean et al., 2013). The MMR vaccine is contraindicated during pregnancy owing to the theoretical risk of live vaccines to the fetus, although inadvertent MMR vaccination during pregnancy has not been associated with an increased risk of adverse outcomes and is not an indication for pregnancy termination (Bar-Oz et al., 2004). Close contacts of pregnant women should ensure their MMR titers are sufficient or should receive an MMR vaccination or booster.

Pregnant HCWs without evidence of measles immunity (seronegative), like all susceptible HCWs, should not enter the rooms of patients with known or suspected measles (Siegel et al., 2007). If exposed to measles, nonimmune pregnant women should receive IVIG treatment within 6 days of exposure (Siegel et al., 2007). Any exposed HCW without evidence of immunity should be excluded from the health care setting from the fifth through the 21st day after exposure (Bolyard et al., 1998; Shefer et al., 2011). If immune, pregnant HCWs may care for patients with measles and should follow airborne and standard precautions, with respiratory protection at least as protective as a fit-tested N95 respirator (Bolyard et al., 1998; Siegel et al., 2007; Shefer et al., 2011).

Herpes simplex virus

Clinical manifestations of HSV infection vary widely. HSV-1 typically causes orofacial infection, whereas HSV-2 is predominantly responsible for genital herpes. However, each viral subtype can affect either anatomic location. Genital herpes is of concern to pregnant women given the risk of vertical transmission and the morbidity and mortality associated with congenital and neonatal infection. When symptomatic, genital herpes presents as painful, pruritic vesicles and ulcers that may be accompanied by headache, fever, dysuria, and tender inguinal lymphadenopathy. Recurrences are typically milder than primary infection, and even a primary infection may be subclinical.

Data suggest that at least 2% of susceptible women in the United States acquire HSV during pregnancy (Brown et al., 1997). Primary HSV infection during pregnancy may rarely lead to life-threatening disseminated disease (Sappenfield et al., 2013; Young et al., 1996), but the greatest risk is vertical transmission. Intrauterine infection is rare, but its occurrence is associated with severe neurologic, ophthalmologic, and cutaneous manifestations,

as well as a high risk of intrauterine or postnatal death (Marquez et al., 2011). More commonly, transmission of HSV to a child is due to contact with virus shed from the genital or perianal region during labor and delivery. Fifty percent to 80% of cases of neonatal HSV infection occur when genital HSV-1 or HSV-2 infection is acquired near term (Brown et al., 1997; Sullender et al., 1988). The risk is greatest when HSV is acquired within 6 weeks of delivery, when there is insufficient time for transplacental delivery of maternal antibodies (Brown et al., 1997). Transmission to the neonate is far less frequent among women who acquire genital herpes during early pregnancy or have a history of recurrent herpes, even if lesions are present at the time of delivery (Foley et al., 2014; Prober et al., 1987).

Women with a history of HSV should be offered daily suppressive acyclovir or valacyclovir starting at 36 weeks of gestation to reduce the likelihood of clinical lesions and viral shedding at delivery (Money and Steben, 2017). Caesarean section is recommended for women with primary genital herpes during the third trimester and for women with a history of genital HSV and either active lesions or prodromal symptoms at the time of labor (Foley et al., 2014; Money and Steben, 2017). Pregnant women should take appropriate precautions to avoid acquiring genital HSV, especially during the third trimester.

Management recommendations

Occupational acquisition of HSV during pregnancy is unlikely owing to the low rates of nosocomial HSV transmission, although contact with infectious lesions or secretions can lead to the development of herpetic whitlow. HCWs who are pregnant or of childbearing age should be counseled on the risks of HSV acquisition during pregnancy, which may pose a danger to the fetus. However, HCWs should not be routinely excluded from caring for patients with HSV solely on the basis of their pregnancy or intent to become pregnant (Bolyard et al., 1998). Nongenital herpes poses minimal risk to the fetus given the low rate of intrauterine infection, and transmission of genital herpes is not an occupational concern because sexual contact is required. All HCWs should follow standard precautions when caring for patients with HSV infection, and additional contact precautions are advised in certain high-risk cases, such as if the HCW is immunocompromised or if the patient has severe, disseminated HSV (Bolyard et al., 1998; Siegel et al., 2007).

Varicella zoster virus

VZV is responsible for varicella (chickenpox) during primary infection and herpes zoster (shingles) upon reactivation. Varicella is typically a mild disease in children, presenting as a diffuse vesicular rash. The rash is often pruritic and consists of lesions at different stages of development. A prodrome of fever, malaise, and myalgia may precede the exanthem. Primary infection is associated with higher morbidity and mortality when it occurs during adulthood, especially in immunocompromised patients and pregnant women. Varicella during pregnancy poses additional risks to the neonate. Herpes zoster typically manifests as a painful and unilateral maculopapular rash with lesions that follow a dermatomal distribution and evolve into vesicles that eventually crust within 7 to 10 days. Herpes zoster during pregnancy is not associated with birth defects or disease in the infant (Enders et al., 1994; Smith and Arvin, 2009).

Varicella is highly contagious. Patients are considered infectious from 48 hours prior to the onset of the rash until the skin lesions have fully crusted. The incidence of varicella is not thought to be higher among pregnant women than nonpregnant adults, and previous reports of greater severity have not been supported by recent studies (Sappenfield et al., 2013). The incidence of VZV infection during pregnancy has been estimated at 0.7 to 3 per 1000 pregnancies (Miller et al., 1993; Sever and White, 1968). Varicella pneumonia is considered the most significant complication of varicella during pregnancy, although a recent large cohort study found the incidence (2.5%) and maternal mortality (0%) to be lower than previously estimated (Zhang et al., 2015).

Transmission of VZV to the fetus can occur in utero, perinatally, or postnatally (Enright and Prober, 2004). Maternal varicella infection during early pregnancy introduces the risk of fetal varicella syndrome (FVS), with the greatest risk (2%) when infection occurs between 13 and 20 weeks of gestation (Enders et al., 1994; Harger et al., 2002; Pastuszak et al., 1994). Characteristic findings in FVS include cutaneous scars in a dermatomal distribution, low birth weight, neurological abnormalities, ocular defects, and limb deformities. FVS is associated with a mortality rate of 30% during the first few months of life (Sauerbrei and Wutzler, 2000). Varicella during the second and third trimesters presents a small risk of herpes zoster during infancy or early childhood (Enders, et al. 1994). Maternal varicella occurring from 5 days before delivery to 2 days after delivery may result in severe neonatal varicella (Smith and Arvin, 2009), characterized by fever, vesicular lesions in various stages of development, and potential progression to disseminated disease (e.g., varicella pneumonia, hepatitis, meningioencephalitis).

Management recommendations

Nonpregnant HCWs without evidence of immunity (seronegative) to VZV should receive the varicella vaccine unless otherwise contraindicated (Shefer et al., 2011). Women should avoid becoming pregnant for 1 month after each injection (Marin et al., 2007). The vaccine is contraindicated during pregnancy due to the theoretical risk of live vaccines to the fetus (Marin et al., 2007), although inadvertent vaccination during pregnancy has not been associated with an increased risk of congenital anomalies (Wilson et al., 2008) and is not an indication for pregnancy termination (Ezeanolue et al., 2019; World Health Organization, 2014). Prenatal assessment for immunity to VZV is recommended for all pregnant women (Marin et al., 2007).

The varicella vaccine should be administered postpartum to nonimmune pregnant HCWs (Marin et al., 2007), and breastfeeding women may be vaccinated safely (Marin et al., 2007). Pregnant HCWs with no evidence of immunity, such as all susceptible HCWs, should avoid contact with patients with confirmed or suspected varicella or herpes zoster (Chin et al., 2014; Kim et al., 2018; Shefer et al., 2011; Siegel et al., 2007). Immunized pregnant HCWs should follow airborne and contact precautions when caring for patients with varicella or disseminated herpes zoster. The same is true when caring for immunocompromised patients with localized zoster until disseminated infection has been ruled out. Because airborne transmission from immunocompetent patients with localized zoster is unlikely, it is sufficient for immunized HCWs to follow standard precautions and cover all lesions until lesions are dry and crusted (Bolyard et al., 1998; Shefer et al., 2011).

All HCWs who are exposed to VZV should be monitored daily during days 8 through 21 after exposure (Shefer et al., 2011). If a susceptible pregnant HCW is exposed, varicella-zoster immune globulin (e.g., VariZIG) should be administered as soon as possible, ideally within 96 hours but up to 10 days after exposure (Marin et al., 2013). Susceptibility should be confirmed by serology testing prior to administration, if possible. Careful monitoring for signs of infection despite passive immunization is essential. Nonimmune HCWs should be furloughed during days 8 through 28 after exposure (Shefer et al., 2011). If symptoms of varicella or disseminated

zoster develop, HCWs should be placed on sick leave until all lesions have crusted over (Chin et al., 2014; Kim et al., 2018; Shefer et al., 2011).

Fetal and maternal monitoring is crucial. Some experts recommend that pregnant women with uncomplicated varicella should receive oral acyclovir. In pregnant women with varicella pneumonia or other serious complications, intravenous acyclovir is advised (American Academy of Pediatrics Committee on Infectious Diseases, 2012a,b,c; Müllegger et al., 2016).

Pityriasis rosea

PR is an acute, self-limiting papulosquamous disorder that characteristically begins with the appearance of a small, isolated, oval plaque referred to as the herald patch. A generalized eruption of smaller, but morphologically similar lesions, appears on the trunk and proximal extremities within 1 to 2 weeks. Their long axes are classically oriented to create a Christmas tree pattern on the back or a V-shaped pattern on the upper chest. Oropharyngeal lesions may rarely be present. Prodromal symptoms may precede the exanthem. Pruritus is reported in approximately 50% of cases (Eisman and Sinclair, 2015), but PR otherwise tends to be asymptomatic and usually resolves spontaneously within 4 to 8 weeks.

The etiology of PR is unclear. Various clinical and epidemiologic features of PR support a viral origin, including its self-limiting course, low recurrence rate, occasional household clustering, possible seasonal variation, prodromal symptoms, response to acyclovir, and higher prevalence during states of impaired immunity (e.g., pregnancy). There is a well-established association between PR and human herpesviruses 6 and 7 (HHV-6/7; Broccolo et al., 2005; Drago et al., 1997, 2009; Watanabe et al., 2002), although many patients show no evidence of active infection with HHV-6/7, and several other viruses (including reactivated HSV-2 in the case of a pregnant woman) have been implicated anecdotally in the pathogenesis of PR (Cruz et al., 2011).

PR occurs most commonly between the ages of 10 and 35 years (Eisman and Sinclair, 2015) with an approximate incidence of 0.5% to 2% (VanRavenstein and Edlund, 2017). It disproportionately affects pregnant women compared with young, nonpregnant women (Corson, 1950), possibly due to increased susceptibility to HHV-6/7 reactivation in the setting of altered immunity.

There are several reports in the literature of healthy, uncomplicated deliveries in patients with PR (Bianca et al., 2007; Chuh et al., 2005; Corson, 1950; Overton, 1968). However, a large case series following 61 patients with gestational PR showed an association with adverse outcomes (Drago et al., 2008, 2014). The overall miscarriage rate among these cases was 13% but increased to 57% if PR developed during the first 15 weeks of gestation. The series suggested that viral reactivation of HHV-6 may have led to intrauterine transmission and subsequent fetal loss. Other unfavorable fetal outcomes reported included premature delivery and neonatal hypotonia. PR development before gestational week 15, the presence of enanthem, and a high HHV-6 viral load were classified as major risk factors for poor outcomes. Constitutional symptoms and involvement of >50% of body surface area were considered minor risk factors (Drago et al., 2018).

Atypical forms of PR may be associated with prolonged viral reactivation in the plasma and potential intrauterine transmission (Drago et al., 2016). The risk of maternal HHV-6 reactivation and intrauterine transmission has been described by others, but low rates of congenital infection (approximately 1%) were reported. Furthermore, most congenital infections occurred due to chromosomal integration rather than transplacental infection (Caserta et al., 2007, 2014). Further studies are needed to substantiate the findings by Drago et al. and elucidate the effects of PR on pregnancy outcomes.

Management recommendations

Recommendations in the literature regarding PR during pregnancy are sparse and based on sparse evidence. Differential diagnoses should be ruled out, with particular attention given to excluding secondary syphilis. Syphilis should especially be considered if a rash is present on the palms or soles. Serologic screening for syphilis is strongly recommended for all pregnant women with suspected PR because there is a serious risk of congenital infection if not promptly treated (Chuh et al., 2005; Mahajan et al., 2016). Drug-related PR-like eruptions should also be considered because these are not associated with viral reactivation and may not pose the same risk to the fetus (Drago et al., 2016). There is one reported case of a PR-like drug eruption due to ondansetron use in a pregnant woman with nausea and vomiting (Alame et al., 2018), but many other drugs are known to cause such eruptions.

Because PR is self-limiting, management is generally limited to reassurance and the treatment of symptoms with emollients, antihistamines, and occasionally topical steroids. However, there are special recommendations for the management of pregnant women. Particularly close monitoring is called for if the mother develops PR within the first 15 to 20 weeks of gestation or experiences constitutional symptoms or an unusually diffuse, prolonged rash (Drago et al., 2008, 2014, 2016; Monastirli et al., 2016). In these cases of atypical PR in pregnant women, conflicting recommendations exist in the literature. Some recommend avoiding systemic therapy (Mahajan et al., 2016), while others recommend considering the use of acyclovir (Chuh et al., 2016; Drago et al., 2015, 2018), which has been shown to hasten the resolution of PR lesions and relieve pruritus. A low-dose regimen (400 mg three times daily for 7 days) is recommended if such intervention is indicated.

Given the potential increased risk of miscarriage during the first 15 weeks of gestation, pregnant HCWs should avoid contact with patients known to have PR during the early stages of pregnancy, if possible, and all pregnant HCWs should use appropriate contact precautions when caring for patients with PR. Although PR is not thought to be contagious and women of childbearing age have likely already been exposed to HHV-6/7, this recommendation is based on the uncertainty surrounding its etiology and the potential danger of infection to the fetus.

Severe acute respiratory syndrome coronavirus 2

Since December 2019, SARS-CoV-2 has resulted in an increasingly devastating global pandemic. In response to the overwhelming number of patients with the novel COVID-19 requiring hospitalization and intensive care unit–level care, many medical providers who do not traditionally perform roles in these settings have been called to assist. The medical community's knowledge of COVID-19 continues to evolve rapidly. Information regarding any potential dermatologic manifestations of the disease, as well as the disease's impact on pregnancy, is limited as of April 2020. Pivotal data from patients in Wuhan, China, have revealed that cutaneous manifestations of COVID-19 are rare, with only 2% of >1000 patients having any type of documented rash (Guan et al., 2019).

Both pregnant HCWs and patients have expressed concern regarding potential complications from COVID-19, although the disease appears to disproportionately affect men compared with women or the pediatric population. Two small retrospective analyses of pregnant women with confirmed COVID-19 pneumonia did

not find evidence of intrauterine vertical transmission or elevated risk of neonatal or fetal complications (Chen et al., 2020; Schwartz, 2020). Another cohort study of 17 pregnant patients, including three HCWs, also did not find conclusive evidence of vertical transmission (Khan et al., 2020). In a separate study of 13 pregnant patients with COVID-19, researchers did not find evidence of vertical transmission but did note that five patients required emergency cesarean section to avoid pregnancy-related complications (Liu et al., 2020).

Although data on pregnant women from previous coronavirus pandemics are limited, pregnant women do not appear to be more likely to acquire SARS-CoV-1 or MERS-CoV, other coronaviruses similar to SARS-CoV-2 that cause SARS and Middle East Respiratory Syndrome, respectively (Rasmussen et al., 2020). However, data from pregnant patients with SARS found that when pregnant women actually did acquire SARS-CoV-1, they tended to have more neonatal and maternal complications, including increased rates of intensive care unit admission and mortality, compared with non-pregnant patients (Lam et al., 2004; Wong et al., 2004).

Management recommendations

As with all HCWs, pregnant HCWs should follow infection-control recommendations from public health officials and abide by occupational health and safety guidelines established by the individual health care systems in which they work. Pregnant HCWs should not provide any clinical care if they test positive for COVID-19. Any pregnant HCW who has symptoms suggestive of COVID-19 should self-isolate after testing for SARS-CoV-2 until results are available. The Royal College of Obstetricians and Gynaecologists recommends that female HCWs who are >28 weeks pregnant avoid direct contact with all patients during the ongoing pandemic, even if the HCW is asymptomatic or has not had contact with patients known or suspected to be infected with COVID-19 (Rimmer, 2020). Those who are <28 weeks pregnant, however, can continue to work in patient-facing roles provided they use proper personal protection equipment (Rimmer, 2020).

Some individual institutions have chosen to prohibit any pregnant HCW, whenever possible, from caring for patients with COVID-19. General principles regarding the management of COVID-19 during pregnancy include early isolation, aggressive infection-control procedures, testing for SARS-CoV-2 and coinfection, oxygen therapy as needed, avoidance of fluid overload, empiric antibiotics (due to secondary bacterial infection risk), fetal and uterine contraction monitoring, early mechanical ventilation for progressive respiratory failure, individualized delivery planning, and a team-based approach with multispecialty consultations (Rasmussen et al., 2020).

Although breastfeeding is not currently contraindicated in patients with COVID-19, it is recommended that patients wear a face mask while breastfeeding to minimize risk of droplet transmission to the newborn (Dashraath et al., 2020). Although SARS-CoV-2 has yet to be identified in breastmilk, newborns are still susceptible to transmission from contact with mothers or other family members, highlighting the importance of proper hand hygiene and social distancing measures.

Conclusion

This review summarizes common exanthematous diseases to which pregnant HCWs may be exposed in the clinical environment. Large trials on outcomes in pregnant women, especially HCWs, are limited. As such, guidelines and recommendations for prevention for pregnant HCWs are limited. Here, we have reviewed and summarized recommendations from the literature. Further research is necessary to evaluate the impact of these measures on prevention. Recommendations should ensure adequate protection for HCWs while limiting unnecessary or cumbersome practices that would unnecessarily prevent pregnant HCWs from performing clinical duties.

In addition, vaccination prior to pregnancy of preventable diseases, such as measles and varicella, is crucial. All clinicians should encourage women of childbearing potential to receive appropriate vaccinations prior to conceiving. Although the CDC provides vaccination recommendations for all HCWs (Advisory Committee on Immunization Practices and CDC, 2011), vaccination laws are typically determined by individual countries or, in the case of the United States, at the state level. The CDC's recommendations for the vaccination of HCWs are summarized in Table 3. Mandated vaccination requirements have been shown to be highly successful. For example, influenza vaccination rates in HCWs have significantly increased when health care institution-based mandates have been implemented in conjunction with government-mandated vaccination requirements (Lin et al, 2016; Wang et al, 2017). All trainees, regardless of sex, should be appropriately vaccinated prior to matriculation in health professional programs, and all HCWs and trainees should demonstrate proof of current immunity prior to working at new sites or institutions.

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Conflict of Interest

None.

References

Adler SP, Manganello AM, Koch WC, Hempfling SH, Best AM. Risk of human parvovirus B19 infections among school and hospital employees during endemic periods. J Infect Dis 1993;168:361–8.

Advisory Committee on Immunization Practices, Centers for Disease Control and Prevention (CDC). Immunization of Health-Care Personnel: Recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2011;60(RR-7):1–45.

Alame MM, Chamsy DJ, Zaraket H. Pityriasis rosea-like eruption associated with ondansetron use in pregnancy. Br J Clin Pharmacol 2018;84(5):1077–80.

Ali ME, Albar HM. Measles in pregnancy: maternal morbidity and perinatal outcome. Int J Gynaecol Obstet 1997;59(2):109–13.

American Academy of Pediatrics. Immunization in special clinical circumstances. In: Pickering LK, Baker CJ, Kimberlin DW, Long SS, editors. Red book: 2012 report of the Committee on Infectious Diseases. Elk Grove Village, IL: American Academy of Pediatrics; 2012a. p. 69–109.

American Academy of Pediatrics. Measles. In: Pickering LK, Baker CJ, Kimberlin DW, Long SS, editors. Red book: 2012 report of the Committee on Infectious Diseases. Elk Grove Village, IL: American Academy of Pediatrics; 2012b. p. 489–99.

American Academy of Pediatrics. Varicella-zoster infections. In: Pickering LK, Baker CJ, Kimberlin DW, Long SS, editors. Red book: 2012 report of the Committee on Infectious Diseases. Elk Grove Village, IL: American Academy of Pediatrics; 2012c. p. 774–89.

American Medical Association. Physician characteristics and distribution in the U.S., 2015 edition [Internet]. 2015 [cited 2019 August 4]. Available from: https://www.aap.org/en-us/Documents/dwmep_women_med_demographics.pdf.

Association of American Medical Colleges. Physician Specialty Data Report: Active Physicians by Sex and Specialty, 2017 [Internet]. 2017 [cited 2019 July 16].

Available from: https://www.aamc.org/data/workforce/reports/492560/1-3-chart.html.
Banta J, Lenz B, Pawlak M, Laskoski K, Seykora C, Webber B, et al. Notes from the field: outbreak of hand, foot, and mouth disease caused by coxsackievirus A6 among basic military trainees — Texas, 2015. MMWR Morb Mortal Wkly 2016;65:678–80.
Bar-Oz B, Levichek Z, Moretti ME, Mah C, Andreou S, Koren G. Pregnancy outcome following rubella vaccination: a prospective controlled study. Am J Med Genet A 2004;130A(1):52–4.
Bell LM, Naides SJ, Stoffman P, Hodinka RL, Plotkin SA. Human parvovirus B19 infection among hospital staff members after contact with infected patients. N Engl J Med 1989;321:485–91.
Bianca S, Ingegnosi C, Ciancio B, Gullotta G, Randazzo L, Ettore G. Pityriasis rosea in pregnancy. Reprod Toxicol 2007;24(3–4):277–8.
Bolyard EA, Tablan OC, Williams WW, Pearson ML, Shapiro CN, Deitchmann SD. Guideline for infection control in healthcare personnel, 1998. Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol 1998;19(6):407–63.
Broccolo F, Drago F, Careddu AM, Foglieni C, Turbino L, Cocuzza CE, et al. Additional evidence that pityriasis rosea is associated with reactivation of human herpesvirus-6 and -7. J Invest Dermatol 2005;124:1234–40.
Brown ZA, Selke S, Zeh J, Kopelman J, Maslow A, Ashley RL, et al. The acquisition of herpes simplex virus during pregnancy. N Engl J Med 1997;337(8):509–16.
Buttery VW, Kenyon C, Grunewald S, Oberste MS, Nix WA. Atypical presentations of hand, foot, and mouth disease caused by coxsackievirus A6–Minnesota, 2014. MMWR Morb Mortal Wkly Rep 2015;64:805.
Canavan TN, Mathes EF, Frieden I, Shinkai K. Mycoplasma pneumoniae-induced rash and mucositis as a syndrome distinct from Stevens-Johnson syndrome and erythema multiforme: a systematic review. J Am Acad Dermatol 2015;72:239–45.
Caserta MT, Hall CB, Canfield RL, Davidson P, Lofthus G, Schnabel K, et al. Early developmental outcomes of children with congenital HHV-6 infection. Pediatrics 2014;134(6):1111–8.
Caserta MT, Hall CB, Schnabel K, Lofthus G, McDermott MP. Human herpesvirus (HHV)-6 and HHV-7 infections in pregnant women. J Infect Dis 2007;196(9):1296–303.
Centers for Disease Control and Prevention. Interim infection prevention and control recommendations for measles in healthcare settings [Internet]. 2019 [cited 2019 August 4]. Available from: https://www.cdc.gov/infectioncontrol/guidelines/measles/index.html.
Centers for Disease Control and Prevention. Pregnancy and non-polio Enterovirus [Internet]. 2019 [cited 2019 July 21]. Available from: https://www.cdc.gov/non-polio-enterovirus/pregnancy.html.
Centers for Disease Control and Prevention. Notes from the field: severe hand, foot, and mouth disease associated with coxsackievirus A6 — Alabama, Connecticut, California, and Nevada, November 2011–February 2012 [Internet]. 2012 [cited 2019 July 21]. Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6112a5.htm.
Chang LY, Tsao KC, Hsia SH, Shih SR, Huang CG, Chan WK, et al. Transmission and clinical features of enterovirus 71 infections in household contacts in Taiwan. JAMA 2004;291:222–7.
Charlier C, Hourrier S, Leruez-Ville M, Zahar JR, Floret D, Salomon LJ, et al. Polyvalent immunoglobulins in neonates after perinatal exposure to measles. J Infect 2015;71(1):131–4.
Chen YH, Keller J, Wang IT, Lin CC, Lin HC. Pneumonia and pregnancy outcomes: a nationwide population-based study. Am J Obstet Gynecol 2012;207(288):e1–7.
Chen H, Guo J, Wang C, Luo F, Yu X, Zhang W, et al. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. Lancet 2020;395(10226):809–15.
Chin TL, MacGowan AP, Jacobson SK, Donati M. Viral infections in pregnancy: advice for healthcare workers. J Hosp Infect 2014;87(1):11–24.
Chow KC, Lee CC, Lin TY, Shen WC, Wang JH, Peng CT, et al. Congenital enterovirus 71 infection: a case study with virology and immunohistochemistry. Clin Infect Dis 2000;31:509–12.
Chuh A, Zawar V, Sciallis G, Kempf W. A position statement on the management of patients with pityriasis rosea. J Eur Acad Dermatol Venereol 2016;30(10):1670–81.
Chuh AA, Lee A, Chan PK. Pityriasis rosea in pregnancy - specific diagnostic implications and management considerations. Aust N Z J Obstet Gynaecol 2005;45(3):252–3.
Corson EF. Coincidence of pityriasis rosea with pregnancy. Arch Dermatol 1950;62(4):562.
Crowcroft N, Roth C, Cohen B, Miller E. Guidance for control of parvovirus B19 infection in healthcare settings and the community. J Publ Health 1999;21:439–46.
Cruz MJ, Baudrier T, Azevedo F. Atypical pityriasis rosea in a pregnant woman: first report associating local herpes simplex virus 2 reactivation. J Dermatol 2011;39(5):490–2.
Dashraath P, Jing Lin Jeslyn W, Mei Xian Karen L, Li Min L, Sarah L, Biswas A, et al. Coronavirus disease 2019 (COVID-19) pandemic and pregnancy. Am J Obstet Gynecol 2020 [Epub ahead of print].
Deeb M, Beach RA, Kim S. Onychomadesis following hand, foot, and mouth disease in a pregnant woman: a case report. SAGE Open Med Case Rep 2019;7. 2050313X19845202.
Drago F, Broccolo F, Javor S, Drago F, Rebora A, Parodi A. Evidence of human herpesvirus-6 and -7 reactivation in miscarrying women with pityriasis rosea. J Am Acad Dermatol 2014;71(1):198–9.
Drago F, Broccolo F, Rebora A. Pityriasis rosea: an update with a critical appraisal of its possible herpesviral etiology. J Am Acad Dermatol 2009;61:303–18.
Drago F, Broccolo F, Zaccaria E, Malnati M, Cocuzza C, Lusso P, et al. Pregnancy outcome in patients with pityriasis rosea. J Am Acad Dermatol 2008;58(5):S78–83.
Drago F, Ciccarese G, Herzum A, Rebora A, Parodi A. Pityriasis rosea during pregnancy: major and minor alarming signs. Dermatology 2018;234(1–2):31–6.
Drago F, Ciccarese G, Rebora A, Broccolo F, Parodi A. Pityriasis rosea: a comprehensive classification. Dermatology 2016;232(4):431–7.
Drago F, Ciccarese G, Rebora A, Parodi A. The efficacy of macrolides and acyclovir in pityriasis rosea. Indian J Dermatol Venereol Leprol 2015;81(1):56.
Drago F, Ranieri E, Malaguti F, Battifoglio ML, Losi E, Rebora A. Human herpesvirus 7 in patients with pityriasis rosea. Electron microscopy investigations and polymerase chain reaction in mononuclear cells, plasma and skin. Dermatology 1997;195:374–8.
Eisman S, Sinclair R. Pityriasis rosea. BMJ 2015;351 h5233.
Enders G, Bolley I, Miller E, Cradock-Watson J, Ridehalgh M. Consequences of varicella and herpes zoster in pregnancy: prospective study of 1739 cases. Lancet 1994;343(8912):1548–51.
Enright AM, Prober CG. Herpesviridae infections in newborns: Varicella zoster virus, herpes simplex virus, and cytomegalovirus. Pediatr Clin North Am 2004;51(4).889–908, viii.
Ezeanolue E, Harriman K, Hunter P, Kroger A, Pellegrini C. General best practice guidelines for immunization. Best practices guidance of the Advisory Committee on Immunization Practices [Internet]. 2019 [cited 2019 July 27]. Available from: www.cdc.gov/vaccines/hcp/acip-recs/generalrecs/downloads/general-recs.pdf.
Foley E, Clarke E, Beckett VA, Harrison S, Pillai A, FitzGerald M, et al. Royal College of Obstetricians & Gynaecologists. Management of genital herpes in pregnancy [Internet]. 2014 [cited 2019 July 30]. Available from: https://www.bashhguidelines.org/media/1060/management-genital-herpes.pdf.
Gershon AA. Chickenpox, measles and mumps. In: Wilson CB, Nizet V, Maldonado Y, Remington J, Klein J, editors. Infectious diseases of the fetus and newborn infant. 6th edition. Philadelphia, PA: Elsevier Saunders; 2006. p. 693.
Giachè S, Borchi B, Zammarchi L, Colao MG, Ciccone N, Sterrantino G, et al. Hand, foot, and mouth disease in pregnancy: 7 years Tuscan experience and literature review. J Matern Fetal Neonatal Med 2019:1–7.
Gillespie SM, Cartter ML, Asch S, Rokos JB, Gary GW, Tsou CJ, et al. Occupational risk of human parvovirus B19 infection for school and daycare personnel during an outbreak of erythema infectiosum. JAMA 1990;263:2061–5.
Gratacós E, Torres PJ, Vidal J, Antolín E, Costa J, Jimenez de Anta MT, et al. The incidence of human parvovirus B19 infection during pregnancy and its impact on perinatal outcome. J Infect Dis 1995;171:1360–3.
Guan W, Ni Z, Hu Y, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. N Engl J Med 2019;2020. https://doi.org/10.1056/NEJMoa2002032.
Harger JH, Ernest JM, Thurnau GR, Moawad A, Thom E, Landon MB, et al. Frequency of congenital varicella syndrome in a prospective cohort of 347 pregnant women. Obstet Gynecol 2002;100(2):260–5.
Harrison J, Jones CE. Human parvovirus B19 infection in healthcare workers. Occup Med (Lond) 1995;45:93–6.
Heller DS, Tellier R, Pabbaraju K, Wong S, Faye-Petersen OM, Muehlenbachs A, et al. Placental massive perivillous fibrinoid deposition associated with coxsackievirus A16-report of a case, and review of the literature. Pediatr Dev Pathol 2016;19:421–3.
Horsten H, Kemp M, Fischer T, Lindahl K, Bygum A. Atypical hand, foot, and mouth disease caused by coxsackievirus A6 in Denmark: a diagnostic mimicker. Acta Derm Venereol 2018;98(3):350–4.
Katta R. Parvovirus B19: a review. Dermatol Clin 2002;20:333–42.
Khan S, Jun L, Nawsherwan, Siddique R, Li Y, Han G, et al. Association of COVID-19 infection with pregnancy outcomes in healthcare workers and general women. Clin Microbiol Infect 2020 [Epub ahead of print].
Kho KA, Eisinger K, Chen KT. Management of an obstetric health care provider with acute parvovirus B19 infection. Am J Obstet Gynecol 2008;198:e33–4.
Kim SH, Park SH, Choi SM, Lee DG. Implementation of hospital policy for healthcare workers and patients exposed to varicella-zoster virus. J Korean Med Sci 2018;33(36) e252.
Kimmis DB, Downing C, Tyring S. Hand-foot-and-mouth disease caused by coxsackievirus A6 on the rise. Cutis 2018;102:353–6.
Lam CM, Wong SF, Leung TN, Chow KM, Yu WC, Wong TY, et al. A case-controlled study comparing clinical course and outcomes of pregnant and non-pregnant women with severe acute respiratory syndrome. BJOG 2004;111(8):771–4.
Lamont RF, Sobel J, Vaisbuch E, Kusanovic JP, Mazaki-Tovi S, Kim SK, et al. Parvovirus B19 infection in human pregnancy. BJOG 2011;118:175–86.
Lara-Medrano R, Martínez-Reséndez MF, Garza-González E, Medina-Torres AG, Camacho-Ortiz A. Outbreak of parvovirus B19 infection among anesthesiology and surgical fellows. Am J Infect Control 2016;44:1069–70.
Lin CJ, Nowalk MP, Raymund M, Sweeney PM, Zimmerman RK. Association of state laws and healthcare workers' influenza vaccination rates. J Natl Med Assoc 2016;108(1):99–102.
Liu Y, Chen H, Tang K, Guo Y. Clinical manifestations and outcome of SARS-CoV-2 infection during pregnancy. J Infect 2020 [Epub ahead of print].

Mahajan K, Relhan V, Relhan AK, Garg VK. Pityriasis rosea: an update on etiopathogenesis and management of difficult aspects. Indian J Dermatol 2016;61(4):375–84.
Marin M, Guris D, Chaves SS, et al., for the Advisory Committee on Immunization Practices, Centers for Disease Control and Prevention (CDC). Prevention of varicella: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2007;56(RR-4):3.
Marin M, Bialek SR, Seward JF. Updated recommendations for use of VariZIG – United States, 2013. MMWR Morb Mortal Wkly Rep 2013;62(28):574–6.
Marquez L, Levy ML, Munoz FM, Palazzi DL. A report of three cases and review of intrauterine herpes simplex virus infection. Pediatr Infect Dis J 2011;30(2):153–7.
Mathes EF, Oza V, Frieden IJ, et al. Eczema coxsackium and unusual cutaneous findings in an enterovirus outbreak. Pediatrics. 2013;132(1):e149–57. https://doi.org/10.1542/peds.2012-3175.
Matsuda Y, Chigusa Y, Kondoh E, Ito I, Ueda Y, Mandai M. A case of macrolide-refractory mycoplasma pneumoniae pneumonia in pregnancy treated with garenoxacin. Case Rep Obstet Gynecol 2017;2017:3520192.
McLean HQ, Fiebelkorn AP, Temte JL, Wallace GS, Centers for Disease Control and Prevention. Prevention of measles, rubella, congenital rubella syndrome, and mumps, 2013: summary recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2013;62(RR-04):1–34.
Miller E, Fairley CK, Cohen BJ, Seng C. Immediate and long term outcome of human parvovirus B19 infection in pregnancy. Br J Obstet Gynaecol 1998;105:174–8.
Miller E, Marshall R, Vurdien J. Epidemiology, outcome and control of varicella-zoster infection. Rev Med Microbiol 1993;4(4):222–30.
Monastirli A, Pasmatzi E, Badavanis G, Tsambaos D. Gestational pityriasis rosea: suggestions for approaching affected pregnant women. Acta Dermatovenerol Croatica 2016;24(4):312–3.
Money DM, Steben M No. 208-Guidelines for the management of herpes simplex virus in pregnancy. J Obstet Gynaecol Canada 2017;39(8):e199–205.
Müllegger RR, Häring NS, Glatz M. Skin infections in pregnancy. Clin Dermatol 2016;34(3):368–77.
Murase C, Akiyama M. Hand, foot, and mouth disease in an adult. N Engl J Med 2018;378 e20.
Neu N, Duchon J, Zachariah P. TORCH infections. Clin Perinatol 2015;42. 77–103, viii.
Ogbuanu IU, Zeko S, Chu SY, Muroua C, Gerber S, De Wee R, et al. Maternal, fetal, and neonatal outcomes associated with measles during pregnancy: Namibia, 2009–2010. Clin Infect Dis 2014;58(8):1086–92.
Ogilvie MM, Tearne CF. Spontaneous abortion after hand-foot-and-mouth disease caused by Coxsackie virus A16. Br Med J 1980;281:1527–8.
Overton RW. Pityriasis rosea in pregnancy: a case report. J Iowa Med Soc 1968;58:1239–40.
Pastuszak AL, Levy M, Schick B, Zuber C, Feldkamp M, Gladstone J, et al. Outcome after maternal varicella infection in the first 20 weeks of pregnancy. N Engl J Med 1994;330(13):901–5.
Prober CG, Sollender WM, Yasukawa LL, Au DS, Yeager AS, Arvin AM. Low risk of herpes simplex virus infections in neonates exposed to the virus at the time of vaginal delivery to mothers with recurrent genital herpes simplex virus infections. N Engl J Med 1987;316(5):240–4.
Ramirez-Fort MK, Downing C, Doan HQ, Benoist F, Oberste MS, Khan F, et al. Coxsackievirus A6 associated hand, foot and mouth disease in adults: clinical presentation and review of the literature. J Clin Virol 2014;60:381–6.
Rasmussen SA, Smulian JC, Lednicky JA, Wen TS, Jamieson DJ. Coronavirus disease 2019 (COVID-19) and pregnancy: What obstetricians need to know. Am J Obstet Gynecol 2020 [Epub ahead of print].
Ray SM, Erdman DD, Berschling JD, Cooper JE, Török TJ, Blumberg HM. Nosocomial exposure to parvovirus B19: low risk of transmission to healthcare workers. Infect Control Hosp Epidemiol 1997;18:109–14.
Riipinen A, Sallmén M, Hedman L, Ojajärvi A, Lindbohm ML, Meriluoto M, et al. Increased risk of human parvovirus B19 infection in day-care employees: a cohort study among pregnant workers during an epidemic in Finland. Occup Environ Med 2014;71:836–41.
Rimmer A. Covid-19: doctors in final trimester of pregnancy should avoid direct patient contact. BMJ 2020;368 m1173.
Sappenfield E, Jamieson DJ, Kourtis AP. Pregnancy and susceptibility to infectious diseases. Infect Dis Obstet Gynecol 2013;2013:1–8.
Sauerbrei A, Wutzler P. The congenital varicella syndrome. J Perinatol 2000;20(8 Pt 1):548–54.
Schwartz DA. An analysis of 38 pregnant women with COVID-19, their newborn infants, and maternal-fetal transmission of SARS-CoV-2: maternal coronavirus infections and pregnancy outcomes. Arch Pathol Lab Med 2020 [Epub ahead of print].
Second J, Velter C, Calès S, Truchetet F, Lipsker D, Cribier B. Clinicopathologic analysis of atypical hand, foot, and mouth disease in adult patients. J Am Acad Dermatol 2017;76:722–9.
Servey J, Reamy BV, Hodge J. Clinical presentations of parvovirus B19 infection. Am Fam Physician 2007;75:373–6.
Sever J, White LR. Intrauterine viral infections 3. Annu Rev Med 1968;19:471–86.
Siegel JD, Rhinehart E, Jackson M, Chiarello L, Health Care Infection Control Practices Advisory Committee. 2007 guideline for isolation precautions: preventing transmission of infectious agents in health care settings. Am J Infect Control 2007;35(10):S65–S164.
Siegel M, Fuerst HT. Low birth weight and maternal virus diseases: a prospective study of rubella, measles, mumps, chickenpox, and hepatitis. JAMA 1966;197(9):680–4.
Siegel M. Congenital malformations following chickenpox, measles, mumps, and hepatitis. Results of a cohort study. JAMA 1973;226(13):1521–4.
Smith CK, Arvin AM. Varicella in the fetus and newborn. Semin Fetal Neonatal Med 2009;14(4):209–17.
Stewart CL, Chu EY, Introcaso CE, Schaffer A, James WD. Coxsackievirus A6-induced hand-foot-mouth disease. JAMA Dermatol 2013;149:1419–21.
Sullender WM, Yasukawa LL, Schwartz M, Pereira L, Hensleigh PA, Prober CG, et al. Type-specific antibodies to herpes simplex virus type 2 (HSV-2) glycoprotein G in pregnant women, infants exposed to maternal HSV-2 infection at delivery, and infants with neonatal herpes. J Infect Dis 1988;157:164–71.
Sungkate S, Phongsamart W, Rungmaitree S, Lapphra K, Wittawatmongkol O, Pumsuwan V, et al. Human parvovirus B19 nosocomial outbreak in healthcare personnel in a paediatric ward at a national tertiary referral centre in Thailand. J Hosp Infect 2017;96:163–7.
Valeur-Jensen AK, Pedersen CB, Westergaard T, Jensen IP, Lebech M, Andersen PK, et al. Risk factors for parvovirus B19 infection in pregnancy. JAMA 1999;281:1099–105.
VanRavenstein K, Edlund BJ. Diagnosis and management of pityriasis rosea. Nurse Pract 2017;42(1):8–11.
Ventarola D, Bordone L, Silverberg N. Update on hand-foot-and-mouth disease. Clin Dermatol 2015;33:340–6.
Wang TL, Jing L, Bocchini JAJ. Mandatory influenza vaccination for all healthcare personnel: a review on justification, implementation and effectiveness. Curr Opin Pediatr 2017;29(5):606–15.
Watanabe T, Kawamura T, Jacob SE, Aquilino EA, Orenstein JM, Black JB, et al. Pityriasis rosea is associated with systemic active infection with both human herpesvirus-7 and human herpesvirus-6. J Invest Dermatol 2002;119:793–7.
Wilson E, Goss MA, Marin M, Shields KE, Seward JF, Rasmussen SA, et al. Varicella vaccine exposure during pregnancy: data from 10 years of the pregnancy registry. J Infect Dis 2008;197(s2):S178–84.
Wong SF, Chow KM, Leung TN, Ng WF, Ng TK, Shek CC, et al. Pregnancy and perinatal outcomes of women with severe acute respiratory syndrome. Am J Obstet Gynecol 2004;191(1):292–7.
World Health Organization. Varicella and herpes zoster vaccines: WHO position paper, June 2014. Wkly Epidemiol Rec 2014;89(25):265–87.
Young EJ, Chafizadeh E, Oliveira VL, Genta RM. Disseminated herpesvirus infection during pregnancy. Clin Infect Dis 1996;22(1):51–8.
Zhang HJ, Patenaude V, Abenhaim HA. Maternal outcomes in pregnancies affected by varicella zoster virus infections: population-based study on 7.7 million pregnancy admissions: Maternal outcomes of VZV infections. J Obstet Gynaecol Res 2015;41(1):62–8.