

Chapter 14: Rubella

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I. Disease Description

Rubella is a viral illness caused by a togavirus of the genus *Rubivirus* and is characterized by a mild, maculopapular rash. The rubella rash occurs in 50%–80% of rubella-infected persons and is sometimes misdiagnosed as measles or scarlet fever. Children usually develop few or no constitutional symptoms, but adults may experience a 1–5-day prodrome of low-grade fever, headache, malaise, mild coryza, and conjunctivitis. Postauricular, occipital and posterior cervical lymphadenopathy is characteristic and precedes the rash by 5–10 days. Arthralgia or arthritis may occur in up to 70% of adult women with rubella. Rare complications include thrombocytopenic purpura and encephalitis.^{1–3} Rubella is transmitted through direct or droplet contact from nasopharyngeal secretions and has an average incubation period of 17 days (range: 12–23 days). Persons with rubella are most infectious when rash is erupting, but they can shed virus from 7 days before to 7 days after rash onset.

When rubella infection occurs during pregnancy, especially during the first trimester, serious consequences can result. These include miscarriages, fetal deaths/stillbirths, and a constellation of severe birth defects known as congenital rubella syndrome (CRS). The most common congenital defects are cataracts, heart defects and hearing impairment. See Chapter 15, “Congenital Rubella Syndrome,” for more details.

II. Background

Before the availability of rubella vaccines in the United States, rubella was a common disease that occurred primarily among young children. Incidence was highest during the spring with epidemics every 6 to 9 years.⁴ The last major epidemic in the United States occurred during 1964–1965, when there was an estimated 12.5 million rubella cases in the United States, resulting in 2,000 cases of encephalitis, 11,250 therapeutic or spontaneous abortions, 2,100 neonatal deaths, and 20,000 infants born with CRS.⁵

In 1969, live attenuated rubella vaccines were licensed in the United States. The goal of the rubella vaccination program was and continues to be to prevent congenital infections, including CRS.⁶ Following vaccine licensure, the number of reported cases of rubella in the United States has declined dramatically to a median of 11 cases annually in 2005–2011 (CDC, unpublished data). During the 1990s, the incidence of rubella among children younger than 15 years decreased (from 0.63 per 100,000 population in 1990 to 0.06 in 1999), whereas the incidence among adults aged 15 to 44 years increased (from 0.13 per 100,000 in 1990 to 0.24 in 1999).⁷ However, since 2001, the incidence both among persons younger than age 15 years and those aged 15 to 44 years has been less than 1/10,000,000 population.^{8,9}

During the 1990s and in 2000, rubella outbreaks occurred among members of religious communities that traditionally refuse vaccination and among adults from countries without a history of routine rubella vaccination programs.^{7,8} Since 2001, only three rubella outbreaks have been reported, each with five or fewer cases.

In 2004, an independent panel of internationally recognized experts in public health, infectious diseases, and immunizations reviewed available data and unanimously agreed that rubella elimination (i.e., the absence of endemic transmission) was achieved in the United States.⁶

Although rubella has been eliminated in the United States, it continues to be endemic in many parts of the world. It is estimated more than 100,000 infants are born with CRS annually worldwide.¹⁰ According to a survey of the member countries in the World Health Organization (WHO), the number of countries that have incorporated rubella-containing vaccines into their routine national immunization programs increased from 83 (13% of the birth cohort) in 1996 to 130 countries (40% of the birth cohort) in 2010. As of October 2010, the WHO Region of the Americas and European Region have established rubella elimination goals for the year 2010 and

2015, respectively; the Western Pacific Region has established targets for accelerated rubella control and CRS prevention goal (<1 case per 100,000) by 2015; and the Eastern Mediterranean Region has established a goal of CRS prevention without a target date for countries that have introduced national rubella vaccination programs.¹¹ In addition, in 2011, WHO recommended for all countries that are providing two doses of measles vaccine and have not introduced rubella vaccine, to consider including rubella-containing vaccine in their immunization program.¹² In 2010, the Pan American Health Organization (PAHO) announced that the Region of the Americas had achieved the rubella and CRS elimination goals set in 2003 based on surveillance data. Although regional documentation of elimination is ongoing, an expert panel unanimously agreed in December 2011 that rubella elimination has been maintained in the United States.^{11, 13}

III. Maintenance of Elimination

The United States has established and achieved the goal of eliminating endemic rubella transmission and CRS. Elimination of endemic rubella was documented and verified in the United States in 2004.⁶ However, because of international travel and countries without routine rubella vaccination, imported cases of rubella are likely. To maintain elimination, the United States should continue to maintain high vaccination rates among children; ensure that women of childbearing age, particularly women born outside of the United States, are vaccinated; and maintain sensitive surveillance to detect both rubella and CRS.

IV. Vaccination

Two combination vaccines are licensed and available in the United States to prevent rubella: MMR vaccine (measles, mumps, and rubella; M-M-R II[®], Merck & Co., Inc.) and tetravalent MMRV vaccine (measles, mumps, rubella, and varicella; ProQuad[®], Merck & Co., Inc.). Monovalent rubella vaccine is no longer available in the United States.

Recommendations for use of rubella-containing vaccines¹⁴

For prevention of rubella, measles, mumps, rubella (MMR) vaccine is recommended for persons aged ≥12 months.

Two doses of MMR vaccine are recommended routinely for children with the first dose at age 12 through 15 months and the second dose at age 4 through 6 years. Because two doses of combined measles-mumps-rubella (MMR) vaccine are recommended in the current schedule for measles and mumps vaccination, most children and adolescents now receive two doses of rubella-containing vaccine.

MMRV vaccine can be used in place of MMR vaccine to implement the two-dose recommendation for children aged 12 months to 12 years.¹⁵

Adults born during or after 1957, including those who may be at increased risk for rubella exposure or transmission, should receive at least one dose of rubella-containing vaccine. These persons include students attending colleges or other post high school educational institutions, healthcare personnel, international travelers, and nonpregnant women of childbearing age. Healthcare providers should routinely assess women of childbearing age for presumptive evidence of rubella immunity (see below) and vaccinate those who lack acceptable evidence of immunity and who are not pregnant. Pregnant women who do not have acceptable evidence of rubella immunity should be vaccinated immediately postpartum.

For unvaccinated healthcare personnel born before 1957 who lack laboratory evidence of rubella immunity or laboratory confirmation of disease, healthcare facilities should consider vaccinating personnel with one dose of MMR vaccine.

V. Presumptive Evidence of Rubella Immunity

Persons who have written documentation of adequate vaccination with at least one dose of live rubella virus-containing vaccine on or after age 12 months, laboratory evidence of rubella immunity, laboratory confirmation of disease, or were born before 1957 (except for women who could become pregnant) have acceptable presumptive evidence of rubella immunity. Birth

before 1957 is not acceptable evidence of rubella immunity for women who could become pregnant. Persons who do not have acceptable presumptive evidence of rubella immunity should receive one dose of MMR vaccine.

VI. Case Definition

Case definition for case classification

The following case definition for rubella has been approved by the Council of State and Territorial Epidemiologists (CSTE) in 2012.¹⁶

Suspected: Any generalized rash illness of acute onset that does not meet the criteria for probable or confirmed rubella or any other illness.

Probable: In the absence of a more likely diagnosis, an illness characterized by all of the following:

- acute onset of generalized maculopapular rash; and
- temperature greater than 99.0° F or 37.2° C, if measured; and
- arthralgia, arthritis, lymphadenopathy, or conjunctivitis; and
- lack of epidemiologic linkage to a laboratory-confirmed case of rubella; and
- noncontributory or no serologic or virologic testing.

Confirmed: A case with or without symptoms who has laboratory evidence of rubella infection confirmed by one or more of the following:

- isolation of rubella virus; or
- detection of rubella-virus specific nucleic acid by polymerase chain reaction; or
- significant rise between acute-and convalescent-phase titers in serum rubella immunoglobulin G antibody level by any standard serologic assay; or
- positive serologic test for rubella immunoglobulin M (IgM) antibody**

OR

An illness characterized by all of the following:

- acute onset of generalized maculopapular rash; and
- temperature greater than 99.0° F or 37.2° C; and
- arthralgia, arthritis, lymphadenopathy, or conjunctivitis; and
- epidemiologic linkage to a laboratory-confirmed case of rubella.

* Not explained by MMR vaccination during the previous 6–45 days.

† Not otherwise ruled out by more specific testing in a public health laboratory.

Epidemiologic classification of internationally-imported and U.S.-acquired

Internationally imported case: An internationally imported case is defined as a case in which rubella results from exposure to rubella virus outside the United States as evidenced by at least some of the exposure period (12–23 days before rash onset) occurring outside the United States and the onset of rash within 23 days of entering the United States and no known exposure to rubella in the United States during that time. All other cases are considered U.S.-acquired cases.

U.S.-acquired case: A U.S.-acquired case is defined as a case in which the patient had not been outside the United States during the 23 days before rash onset or was known to have been exposed to rubella within the United States. U.S.-acquired cases are subclassified into four mutually exclusive groups:

Import-linked case: Any case in a chain of transmission that is epidemiologically linked to an internationally imported case.

Imported-virus case: A case for which an epidemiologic link to an internationally imported case was not identified but for which viral genetic evidence indicates an imported rubella genotype, i.e., a genotype that is not occurring within the United States in a pattern indicative of endemic transmission. An endemic genotype is the genotype of any rubella virus that occurs in an endemic chain of transmission (i.e., ≥ 12 months). Any genotype that is found repeatedly in U.S.-acquired cases should be thoroughly investigated as a potential endemic genotype, especially if the cases are closely related in time or location.

Endemic case: A case for which epidemiological or virological evidence indicates an endemic chain of transmission. Endemic transmission is defined as a chain of rubella virus transmission continuous for ≥ 12 months within the United States.

Unknown source case: A case for which an epidemiological or virological link to importation or to endemic transmission within the United States cannot be established after a thorough investigation. These cases must be carefully assessed epidemiologically to assure that they do not represent a sustained U.S.-acquired chain of transmission or an endemic chain of transmission within the United States.

Note: Internationally imported, import-linked, and imported-virus cases are considered collectively to be import-associated cases.

States may also choose to classify cases as “out-of-state-imported” when imported from another state in the United States. For national reporting, however, cases will be classified as either internationally imported or U.S.-acquired.

VII. Laboratory Testing

Clinical diagnosis of rubella is unreliable, therefore, cases must be laboratory confirmed. Virus detection and serologic testing can be used to confirm acute or recent rubella infection. Serologic tests can also be used to screen for rubella immunity. For additional information on laboratory testing for the surveillance of vaccine-preventable diseases, see Chapter 22, “Laboratory Support for Surveillance of Vaccine-Preventable Diseases.”

Virus detection (real-time RT-PCR, RT-PCR)

Rubella virus can be detected from nasal, throat, urine, blood, and cerebrospinal fluid specimens from persons with rubella (see Appendix 15). The best results come from throat swabs. Cerebrospinal fluid specimens should be reserved for persons with suspected rubella encephalitis. Efforts should be made to obtain clinical specimens for virus detection from all case-patients at the time of the initial investigation. Virus may be detected from 1 week before to 2 weeks after rash onset. However, maximum viral shedding occurs up to day 4 after rash onset.

Real-time RT-PCR and RT-PCR can be used to detect rubella virus and has been extensively evaluated for its usefulness in detecting rubella virus in clinical specimens.^{17, 18} Clinical specimens obtained for virus detection and sent to CDC are routinely screened by these techniques.

Molecular typing is recommended because it provides important epidemiologic information to track the epidemiology of rubella in the United States now that rubella virus no longer continuously circulates in this country. By comparing virus sequences obtained from new case-patients with other virus sequences, the origin of particular virus types in this country can be tracked.¹⁹ Furthermore, this information may help in documenting the maintenance of the elimination of endemic transmission. In addition, genotyping methods are available to distinguish wild-type rubella virus from vaccine virus.

Serologic testing

The serologic tests available for laboratory confirmation of rubella infections and immunity vary among laboratories. The State health department can provide guidance on available laboratory services and preferred tests. Enzyme immunoassays (EIA) are the most commonly

used and widely available diagnostic test for rubella IgG and IgM antibodies and are sensitive and relatively easy to perform. EIA is the preferred testing method for IgM, using the capture technique, although indirect assays are also acceptable.

Latex agglutination (LA) tests appear to be sensitive and specific for screening when performed by experienced laboratory personnel. Other tests in limited use to detect rubella-specific IgM include hemagglutination inhibition (HI) and immunofluorescent antibody (IFA) assay.

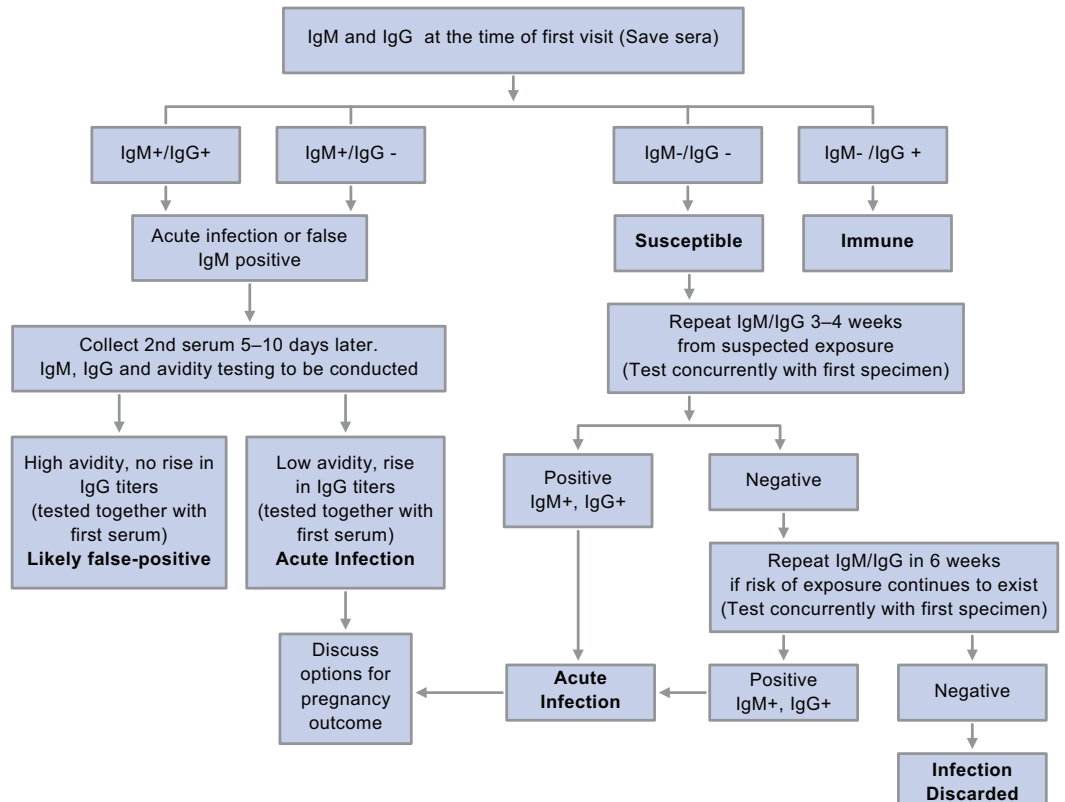
Detection of IgM antibody

Rubella-specific IgM can usually be detected 4–30 days after onset of illness, and often for longer. Sera should be collected as early as possible after onset of illness. However, IgM antibodies may not be detectable before day 5 after rash onset. In case of a rubella IgM-negative result in specimens taken before day 5, serologic testing should be repeated on a specimen collected after day 5.

Because rubella incidence is low, a high proportion of IgM-positive tests will likely be false positive. False-positive serum rubella IgM tests may occur due to the presence of rheumatoid factors (indicating rheumatologic disease) or cross-reacting IgM, or infection with other viruses.^{20,21} Avidity testing (see below) and detection of wild-type rubella virus can be used to resolve uncertainties in the serologic evaluation of suspected cases.

Particular care should be taken when rubella IgM is detected in a pregnant woman with no history of illness or contact with a rubella-like illness. Although this is not recommended, many pregnant women with no known exposure to rubella are tested for rubella IgM as part of their prenatal care. If rubella test results are IgM-positive for persons who have no or low risk of exposure to rubella, additional laboratory evaluation should be conducted. Laboratory evaluation is similar to that described in the IgM-positive section of Figure 1.

Figure 1. Algorithm for serologic evaluation of pregnant women exposed to rubella



Detection of IgG antibody (significant rise or avidity) for diagnostic testing

To detect a significant rise in rubella-specific IgG concentration, the first serum should be obtained as soon as possible after onset of illness and the second serum sample should be collected about 7–21 days after the first specimen. In most rubella cases, rubella IgG is detectable by 8 days after rash onset.²² Tests for IgG antibody should be conducted on both acute-and convalescent-phase specimens at the same time with the same test.

Assays for IgG avidity are useful to distinguish the difference between recent and past rubella infections. Low avidity is associated with recent primary rubella infection, whereas high avidity is associated with past infection or reinfection. Avidity tests are not routine tests and should be performed in reference laboratories. A number of avidity assays have been described.^{23, 24}

Detection of IgG antibody to screen for rubella immunity

A single serologic IgG test may be used to determine the rubella immune status of persons whose history of rubella disease or vaccination is unknown. The presence of serum IgG rubella-specific antibodies indicates immunity to rubella.

VIII. Importance of Rubella Surveillance

Surveillance data are needed to identify and control rubella virus introductions to prevent congenital rubella infections and consequent CRS as well as monitor maintenance of disease elimination.

Promote awareness of rubella and CRS in the United States

Although only 62 cases of rubella and 4 cases of CRS were reported between 2005 and 2011, it is likely that not all cases were identified. Efforts should continue to promote physicians' awareness of the possibility of rubella and CRS. When evaluating patients with suspected measles who have negative serologic tests for acute measles infection (i.e., negative serum measles IgM), officials may request additional testing for rubella.

Promote awareness of groups at high risk for rubella infection and CRS birth

Rubella-containing vaccines are not administered routinely in many countries, and in others, rubella-containing vaccine was only recently added to the childhood immunization schedule. Thus, many persons born outside the United States or who received childhood immunizations in other countries may have never received rubella vaccine. Healthcare providers should have a heightened index of suspicion for rubella and CRS births in persons from countries without a history of routine rubella vaccination programs or with recently implemented programs.

IX. Reporting

Each state and territory has regulations or laws governing the reporting of diseases and conditions of public health importance.²⁵ These regulations and laws list the diseases to be reported and describe those persons or groups who are responsible for reporting, such as healthcare providers, hospitals, laboratories, schools, daycare and childcare facilities, and other institutions. Persons reporting should contact the State health department for state-specific reporting requirements.

Prompt identification and reporting of suspected, probable, or confirmed cases of rubella is important to avoid exposure of susceptible pregnant women. Rapid case identification and investigations are also important so that control measures can be initiated to prevent spread of the disease.

Reports of rubella are designated by CSTE as “immediately notifiable, urgent” which requires notification of the CDC within 24 hours. All cases of rubella should be reported by the State health department to CDC/NCIRD/DVD/Epidemiology Branch (404-639-8253) and to the National Notifiable Diseases Surveillance System (NNDSS). Reporting should not be delayed because of incomplete information or laboratory confirmation; following completion of case investigations, data previously submitted to NNDSS should be updated with the available new information.

The following data elements are epidemiologically important and should be collected in the course of a case investigation. Additional information may be collected at the direction of the state or local health department.

- Demographic information
 - Name
 - Address
 - Age
 - Sex
 - Ethnicity
 - Race
 - Country of birth
 - Length of time in United States
- Reporting Source
 - County
 - Earliest date reported
- Clinical
 - Date of illness onset
 - Date of rash onset
 - Duration of rash
 - Symptoms
 - Fever
 - Arthralgia or arthritis
 - Lymphadenopathy
 - Conjunctivitis
 - Complications
 - Encephalitis
 - Thrombocytopenia
 - Other
 - Hospitalizations and duration of stay
 - Outcome (patient survived or died)
 - Date of death
 - If female, pregnancy history
 - If pregnant, pregnancy status
 - ◻ Number of weeks gestation at onset of illness
 - ◻ Prior evidence, date of serologic immunity, or both
 - ◻ Prior diagnosis and date of rubella
 - ◻ Number and dates of previous pregnancies and location (e.g., state or country) of these pregnancies
 - ◻ Pregnancy outcome, when available (e.g., normal infant, termination, CRS)
- Laboratory
 - Serology
 - Virus isolation
 - Genotype
 - PCR results
- Vaccine Information
 - Number of doses of rubella-containing vaccine received
 - Dates of vaccination
 - Types of vaccine (rubella, MMR, MMRV)
 - If not vaccinated, reason

- Epidemiologic
 - Transmission setting (infection acquired at home, healthcare setting, in daycare, school, or workplace)
 - Relationship to outbreak (Is case part of an outbreak or is it sporadic?)
 - Source of exposure
 - Travel history (countries, dates)

X. Case Investigation, Contact Investigations, and Outbreak Control

Consider a single case of rubella as a potential outbreak

Because rubella has been eliminated in the United States, health agencies should consider one case a potential outbreak. Rubella is an infectious disease for which up to 50% of cases are asymptomatic, and investigation of an apparently isolated case could reveal additional cases.

Confirm a diagnosis of rubella

Clinical diagnosis of rubella is unreliable, therefore, cases must be laboratory confirmed, especially if the reported cases are not epidemiologically linked to a laboratory-confirmed case. Laboratory testing should be conducted for all suspected cases of rubella.

Laboratory confirmation of rubella infection may be difficult in pregnant women with unknown immune status who experience a rash illness or who are exposed to rubella. A serum specimen should be obtained as soon as possible.

Conduct case investigations and vaccinate contacts without evidence of immunity

Aggressive response to rubella cases may interrupt disease transmission and will increase vaccination coverage among persons who might otherwise not be protected. The main strategies are to define populations at risk, to ensure that persons without evidence of immunity are rapidly vaccinated (or excluded from exposure if a contraindication to vaccination exists) and to maintain active surveillance to permit modification of control measures if the situation changes.

The goal of rubella case investigation is to identify rubella infections, particularly infection in pregnant women, and to prevent exposure of susceptible pregnant women, and thereby prevent cases of CRS. It is essential that exposed pregnant women be identified, evaluated, and counseled (see section on laboratory evaluation of exposed pregnant women). The Rubella Surveillance Worksheet (see Appendix 16) may be used as a guideline in conducting a case investigation. Case investigation and identification of contacts should be conducted for all suspected cases of rubella.

Cases of rubella occurring within 10 days of rubella vaccination should be investigated, and specimens should be obtained for virus isolation to determine if the rash is attributable to vaccine virus or wild virus. Cases in persons vaccinated within 7 days of a rubella-like illness who are IgM-positive should be classified as confirmed cases of wild-type rubella if they are epidemiologically linked to a laboratory-confirmed case.

Any direct contact with a patient with rubella during the infectious period (7 days before to 7 days after rash onset) is defined as an exposure. Every effort should be made to identify all pregnant women who might have been exposed to a patient and evaluate them serologically for rubella-specific IgM and IgG antibodies. All women of childbearing age who are contacts of a person with a suspected or confirmed case should have their pregnancy status determined. If a pregnant woman is infected with rubella, immediate medical consultation is necessary. If a pregnant woman lacks laboratory evidence of rubella immunity, precautions should be taken to prevent any type of exposure to persons infected with rubella; these precautions may include ensuring rubella immunity of household contacts and isolating women from settings where rubella virus has been identified.

Identify the source of infection

Efforts should be made to identify the source of infection for every confirmed case of rubella. Case-patients or their caregivers should be asked about contact with other known cases. Since many rubella cases are asymptomatic, identification of a source will not always be possible. When no history of contact with a known case can be elicited, opportunities for exposure to unidentified cases in populations at high risk (e.g., foreign-born persons) should be sought. Investigating sources of exposure should be directed to the place and time period in which transmission would have occurred.

Obtain specimens for virus detection

Efforts should be made to obtain clinical specimens (throat swabs and urine) for virus detection from all case-patients (or from at least some patients in each outbreak) at the time of the initial investigation.

See Appendix 15 for the procedure to follow in collection of specimens.

Conduct laboratory evaluation of exposed pregnant women

Exposed pregnant women should be tested for the presence of rubella IgG and IgM antibodies as outlined in Figure 1 regardless of symptom history. A blood specimen should be taken as soon as possible and tested for rubella IgG and IgM antibody and stored for possible retesting.

- If the IgM is positive regardless of the IgG response, this may indicate recent or acute infection or a false-positive IgM. The next step is testing with a serum collected in 5–10 days. Testing will include IgM, IgG, and avidity (if IgG is present). If the repeat IgM is positive with low avidity or a significant rise in IgG titers, acute infection is likely. If the IgM and IgG are positive and the avidity is high, this may indicate either a false-positive result or a reinfection. Reinfection with rubella occurs more frequently with vaccine-induced immunity than with natural disease; however, the risk of fetal infection is extremely low.
- If the IgM is negative and the IgG is positive at the time of exposure (the first specimen), this most likely indicates immunity.
- If the IgM and IgG are negative in the first specimen, a second specimen should be taken 3–4 weeks after exposure and tested concurrently with the first specimen for IgM, IgG, and avidity (if IgG is present). A negative IgG response with the first specimen and a positive IgG response with the second specimen indicate that infection has occurred. If the IgG and IgM remain negative and there are no additional exposures, an IgG-negative result at 4 weeks indicates that infection has not occurred. As long as the exposure to rubella continues, it is important to continue testing for IgG and IgM responses.

Report the pregnancy outcome for women diagnosed with rubella during pregnancy

All pregnant women infected with rubella during pregnancy should be followed to document the pregnancy outcome (e.g., normal infant, termination, CRS). Outcomes that are documented should be reported to CDC.

Conduct enhanced surveillance

Active surveillance for rubella should be maintained for at least two incubation periods (46 days) following rash onset of the last case. Two incubation periods allow for the identification of transmission from a subclinical case. In addition, surveillance for CRS should be implemented when confirmed or probable rubella cases are documented in a setting where pregnant women might have been exposed. Women who contract rubella infection while pregnant should be monitored for birth outcome, and appropriate testing should be performed on the infant after birth.

Implement control measures

Control measures should be implemented as soon as at least one case of rubella is confirmed in a community. In settings where pregnant women may be exposed, control measures should begin as soon as rubella is suspected and should not be postponed until laboratory

confirmation. Patients with rubella should be isolated for 7 days after rash onset. All persons at risk who cannot readily provide acceptable evidence of rubella immunity should be considered susceptible and should be vaccinated.

In schools and other educational institutions, exclusion of persons without acceptable evidence of rubella immunity may limit disease transmission and may help to rapidly raise the vaccination level in the target population. All persons who have been exempted from rubella vaccination for medical, religious, or other reasons also should be excluded from attendance. Exclusion should continue until 23 days after the onset of rash of the last reported case-patient in the outbreak setting. Unvaccinated persons who receive MMR vaccine as part of the outbreak control may be immediately readmitted to school provided all persons without documentation of immunity have been excluded.

In healthcare settings, exposed healthcare personnel without adequate presumptive evidence of immunity should be excluded from duty beginning 7 days after exposure to rubella and continuing through either 23 days after last exposure or 7 days after rash appears. Exposed healthcare personnel who are vaccinated as part of control measures should be excluded from direct patient care for 23 days after the last exposure to rubella because effectiveness of postexposure vaccination in preventing rubella infection has not been shown. In addition, because birth before 1957 does not guarantee rubella immunity, during outbreaks in healthcare settings, healthcare facilities should recommend one dose of MMR vaccine for unvaccinated personnel born before 1957 who lack laboratory evidence of rubella immunity or laboratory confirmation of infection or disease.²⁶

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