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Commentary

Infection prevention and control for measles in healthcare settings

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Abstract

Healthcare facilities in the U.S. are well positioned to assist with measles control by timely identification and isolation of suspected or confirmed cases and, as measles is nationally notifiable, by informing local health departments about both suspected and confirmed cases. However, responding to measles cases in acute healthcare settings presents unique challenges, is disruptive, and requires an intense outlay of resources before, during, and afterward primarily due to exposure investigations. We describe our measles preparedness efforts to improve identification of measles cases, facilitate appropriate isolation, reduce exposures, and provide timely post-exposure prophylaxis.

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Introduction

The global burden of measles is staggering. In 2023, measles infected ~10,300,000 people, which represented a 20% increase compared with 2022,[1,2] and resulted in 107,500 measles-related deaths, mostly in children under 5 years of age. This surge reflected inadequate vaccination including those not vaccinated or under-vaccinated. Worldwide, the proportion of children receiving their first dose of measles vaccine has decreased; in 2023, 83% of eligible children received their first dose compared with 86% in 2019.

Measles vaccine is highly effective; one dose is 93% and two doses are 97% effective at preventing measles. The World Health Organization estimates that measles vaccine averted ~60 million deaths between 2000 and 2023.[1] However, to prevent outbreaks and protect those who cannot receive the vaccine (eg, young infants or immunocompromised individuals), at least 95% of the population must be vaccinated. This goal seems progressively elusive as vaccination rates decline in regions with fragile public health infrastructure, conflicts, or where anti-vaccination movements flourish. In the U.S. vaccine hesitancy, exacerbated by the COVID-19 pandemic, has led to declines in measles vaccination rates. Herd immunity is estimated to be 92% and ~13% of children are non-immune.[3] In addition, measles vaccination of non-immune adults is critical given the risks to healthcare personnel, students at educational institutions after high school, international travelers, and pregnant individuals.

Despite tremendous efforts to control measles in the U.S., the impact of measles can be substantial if imported cases of measles occur in non-immune individuals traveling from other countries where vaccine coverage is low.[4] Sustained transmission of measles has also been observed in U.S. communities with low vaccination rates due to vaccine hesitancy.[5,6] From January to November 2024, 280 measles cases were reported with the largest number of cases in Minnesota and Illinois.[7] Approximately 70% of these cases were associated with clusters or outbreaks, as defined by the Centers for Disease Control and Prevention (CDC) as three or more cases. Analogous to the global epidemiology, the majority (89%) of cases were unvaccinated or had unknown vaccination status and 41% were under 5 years of age. Notably, 28% of cases occurred in adults and overall, 40% of cases were hospitalized, thereby placing others at risk of exposure to measles in healthcare settings.

Nonetheless, healthcare facilities in the U.S. are well positioned to assist with measles control by timely identification and isolation of suspected or confirmed cases and as measles cases are nationally notifiable, by informing local health departments. The expertise of health departments can be invaluable to investigate measles cases and manage outbreaks and exposures.

Measles preparedness

Measles cases in acute healthcare settings present unique challenges, are disruptive and require an intense outlay of resources before, during, and afterward, primarily due to exposure investigations. Over the past decade, our Department of Infection Prevention and Control's (IP&C) multidisciplinary team has coordinated multiple exposure investigations. We have refined our measles preparedness efforts to improve identification of measles cases, facilitate appropriate isolation, reduce exposures, and provide timely post-exposure prophylaxis (PEP). In this commentary, we share our readiness tools which are always in place and updated as needed and response tools which are implemented when suspected or confirmed measles cases present to our academically affiliated, multi-campus healthcare system. We share the challenges we have encountered, and potential solutions implemented during our preparedness efforts (Table 1) and present two recent illustrative cases.

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Table 1. Challenges encountered and potential solutions implemented during measles preparedness efforts[1]

Challenges	Potential Solutions
Measles Readiness	
Education	
Lack of familiarity by front-line staff with measles presentations Nonspecific prodromal symptoms	• Improved partnerships with key stakeholders and local champions for high-consequence infectious diseases, including measles • Development and dissemination of educational tools, eg, ○ Algorithms for measles in ED, clinics, and inpatients ○ FAQs: Healthcare Personnel & Staff Immunity to Measles ○ Multi-lingual patient and visitor information
Laboratory Support	
Lack of local laboratory resources to test for measles requiring testing by health department Lack of familiarity with testing workflow by staff can delay diagnosis.	• Develop EMR order set including: ○ **Send out orders**: Respiratory sample to detect measles RNA by reverse-transcriptase PCR assay and serum sample to detect measles-specific IgM by enzyme-linked immunosorbent assay ○ **Local orders:** Serum sample for measles IgG (can determine immunity and rule out measles) • Develop and post detailed instructions for DOH testing with images of appropriate tubes/ swabs and links to DOH paper forms
Measles Exposure Response	
Coordination with stakeholders	
Multidisciplinary resources required to identify exposed individuals and determine eligibility for PEP Reduced resources off hours	• Create and share workflow and checklist to set expectations for different disciplines (eg, unit leadership, laboratory personnel, patient services) • Establish exposure management team • Create contact list of supervisors • Exchange contact information with DOH
Identifying exposed individuals	
Large number of exposed patients, staff, and family members/ visitors Exposed family members/ visitors may not be patients in our healthcare system and may be at risk for severe measles, eg, infants, pregnant women	• Create comprehensive clinical trace tool in EMR to identify exposed patients and staff • Share responsibility of contacting exposed patients with ambulatory providers when feasible • Use of patient scripts provided by DOH that describe exposure and possible PEP
Providing post-exposure prophylaxis	
Providing timely PEP	• Create priority groups for PEP administration ○ Group 1 – unimmunized infants ≥ 6 mo and children eligible for their first dose of MMR within 72 h of exposure ○ Group 2 - infants <6 mo, infants 6–11 mo of age who did not receive MMR PEP, non-immune pregnant people, or immunocompromised individuals, including those born prior to 1957 eligible for IG within 6 d of exposure ○ Group 3 - those who received one prior measles vaccine and eligible for second dose
Unknown immune status of exposed individuals	• Use residual serum in laboratory obtained for other purposes to test for measles IgG, if available • Order measles IgG for hospitalized patients • Providers can test exposed visitors for measles IgG • Can safely administer MMR to exposed individuals who may have received prior doses
Caring for exposed individuals during their incubation period	
Follow up visits, tests, or procedures that cannot be postponed for exposed patients with complex comorbid condition who received PEP IG	• Provider contacts patient and accompanying family member to confirm they are asymptomatic • Patient and family member placed in Airborne isolation room if available • If no Airborne Isolation room available (eg, ambulatory clinic): ○ Schedule as last visit, if feasible ○ Patient and family member don surgical mask ○ Place immediately in room with closed door ○ Provide phlebotomy in clinic, rather than phlebotomy unit, if feasible

[1]Abbreviations used in table: ED, emergency department; FAQ, frequently asked questions; EMR, electronic medical record; PEP, post-exposure prophylaxis; DOH, department of health; IG – immunoglobulin.

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A mother and infant with measles

A previously healthy 6-month-old boy presented to the pediatric ED with 1-2 days of fever, cough, post-tussive emesis, and non-bloody diarrhea. He did not have a rash. The multiplex PCR respiratory pathogen panel was negative. The following day he returned to the ED with persistent fever, increased irritability, and continued cough, congestion, and diarrhea. He was hospitalized for 24 hours to observe his oral intake. Three days later, he returned to the ED with persistent fever and new progressive rash. At the same time, his mother was in the adult ED with fever and rash. Airborne isolation in a negative pressure room was initiated within 2 hours of the infant's third ED presentation but had not been initiated during the previous ED admissions and hospitalization.

The infant's mother, a previously healthy 20-year-old woman, presented to the adult ED with one week of cough, sore throat, and fever and three days of rash. The rash started on her face and torso and spread to the rest of her body. She was born in Mexico, had a negative measles IgG during pregnancy, and declined MMR vaccine after delivery. The hospital epidemiologist and health department were contacted for suspected measles. Airborne isolation in a negative pressure room was initiated within 50 minutes of the mother's presentation to the ED.

Several hours later, the health department reported that another individual living in the same apartment building, but not a household contact, had been diagnosed with measles and was the likely source case for the infant and mother. The infant and mother's respiratory samples were positive for measles.

Measles readiness strategies

We acknowledge the challenge of maintaining readiness for a relatively rare infectious disease amidst competing priorities, fatigue, and the potential burnout that can be experienced by healthcare workers (HCWs). To address this challenge, we have expanded local champions for high-consequence infectious diseases, including measles, from our emergency departments (EDs) and ambulatory care network which improves our understanding of the workflows and practice patterns across our healthcare system. We have enhanced our partnership and communication with key stakeholders including medical and nursing leadership, administrative leadership, Workforce Health & Safety (WH&S), security, pharmacy, laboratory leadership, environmental service workers (EVS, ie, housekeeping), patient services, and student health. Our ability to harness computer-decision support to identify potential measles cases in the absence of a known local outbreak, a travel history, or exposure to a known case of measles has been elusive. However, we continue to seek successful models from other healthcare systems.

Education

Numerous cases of measles were presented to our healthcare system during 2014 and 2019 measles outbreaks in the New York metropolitan area.[5,8,9] We consistently recognized that education and booster education were needed for front-line staff that described the clinical presentations and isolation requirements for measles. Today, few HCWs in the U.S. have seen a case of measles and thus are unfamiliar with the prodrome or the rash's appearance and progression. The differential diagnosis of fever, respiratory symptoms, and rash are broad which creates challenges for prompt identification and isolation.[9] Thus, our healthcare system developed educational tools posted on our internal website and ready for use for front-line staff caring for patients with suspected or confirmed measles (Table 1). Examples of these educational tools include algorithms for the EDs (Figure 1) and inpatients with measles (Figure 2), and Frequently Asked Questions: Healthcare Personnel and Staff Immunity to Measles (Supplemental Figure 1). An additional focus has been to seek the input of key stakeholders if these documents are revised. We also developed educational materials about isolation and visitation for patients and visitors using health department and CDC templates.[10,11]

Partnering with workforce health and safety

It is important for Workforce Health and Safety (WH&S) to maintain an up-to-date list of the measles immune status of HCWs and non-clinical staff, eg, security personnel and EVS. In the event of exposure, this allows IP&C to quickly determine if any exposed staff are non-immune and require PEP. Maintaining an up-to-date list gives WH&S the opportunity to vaccinate staff previously ineligible to receive measles vaccine but whose health status now allows live viral vaccines to be provided.

Collaboration with health department for laboratory testing for measles

Another challenge to measles readiness has been the lack of local laboratory resources to test patients for measles infection. In our jurisdiction, providers caring for a patient with suspected measles must discuss the case with the health department's on-call physician and obtain approval for testing. While IP&C must frequently remind providers of this process, it does allow us access to the expertise of the health department including familiarity with regional and global epidemiology. Once a compatible clinical case is approved for testing, samples are hand-delivered to our local laboratory, picked up by a health department courier, and delivered to the public health laboratory. Due to the unfamiliar workflow, delays in diagnosis can occur if the wrong specimen tubes are used, or the forms are incorrectly filled out.

To address the challenge of testing, we developed an order set for the health department samples linked to detailed instructions and images of the appropriate specimen tubes, swabs and transport media (Table 1). We also removed the ability to order measles IgM which previously could be sent to a commercial laboratory with a prolonged turnaround time.

Measles response

Coordination with stakeholders during exposure investigations

Performing exposure investigations requires a large hospital-based team collaborating with the health department. Identifying exposed individuals and providing PEP takes the largest expenditure of time and resources. Over time, we have refined our exposure response and implemented a workflow/ checklist to guide our exposure investigations, including the roles of key stakeholders (Figure 3). Our exposure management team consists of the hospital epidemiologist responsible for the facility where the exposure occurred, infection preventionists responsible for the exposure unit(s), and nursing and medical leadership from

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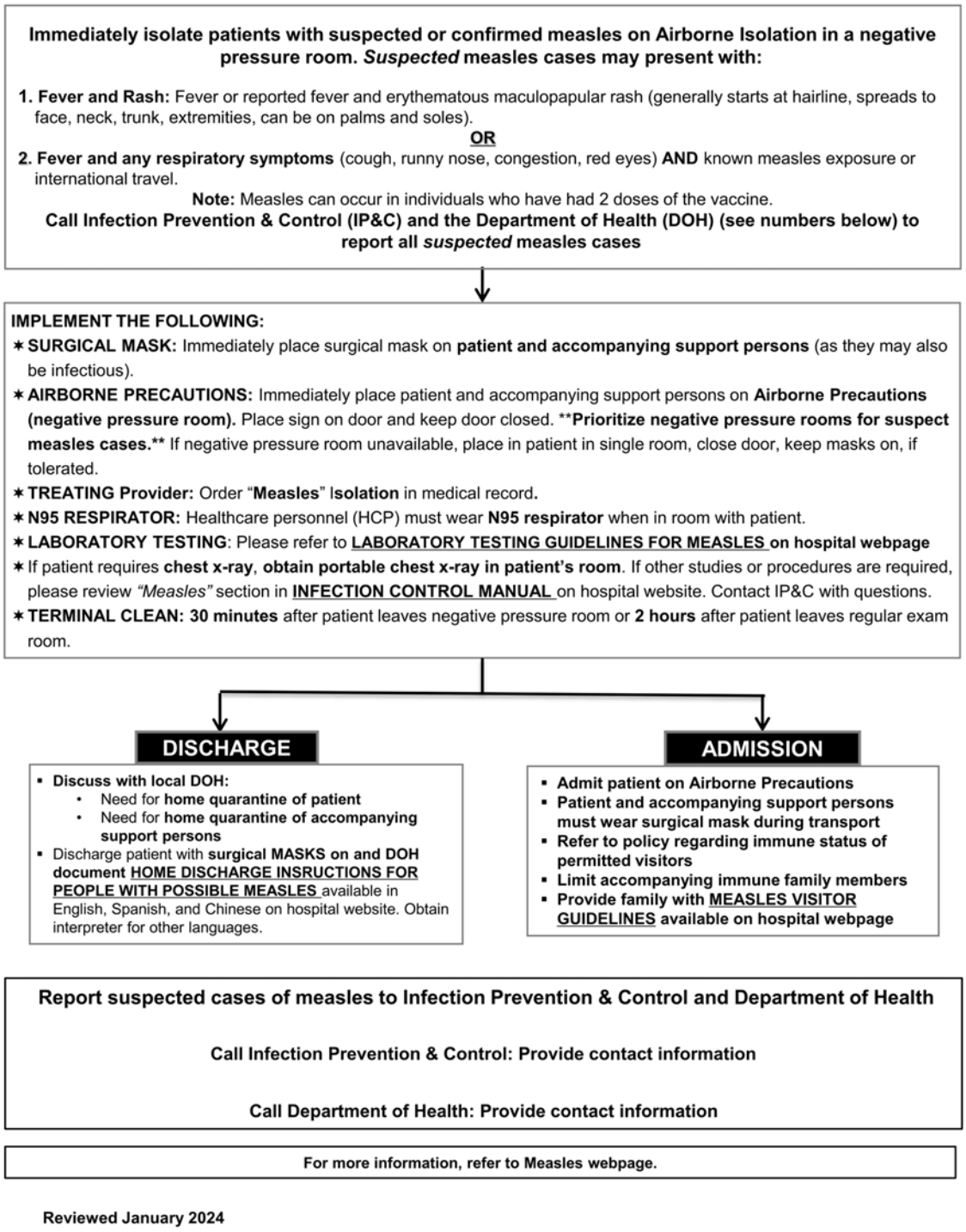

Figure 1. Suspected or confirmed measles case in ED. This algorithm describes the steps needed to appropriately identify and isolate patients with suspected or confirmed measles and provides links to relevant documents and contact information.

that unit. For larger exposures, we have the option of activating our existing command center. During the exposure investigation, the management team meets daily to review progress in contacting exposed individuals and providing PEP. The health department requires regular updates about the status of the exposure investigation, provision of PEP, and updated line lists. Future advancements could include the development of a health department digital platform to coordinate these efforts. It is particularly challenging to coordinate a response for a measles case off hours, during weekends, and holidays when staffing is lower, and key stakeholders are not scheduled to work, eg, WH&S.

Determining the exposure window

The incubation period for measles is 7 to 21 days and individuals with measles are infectious 4 days prior to rash and until 4 days after rash onset. As measles is transmitted by the airborne route, patients

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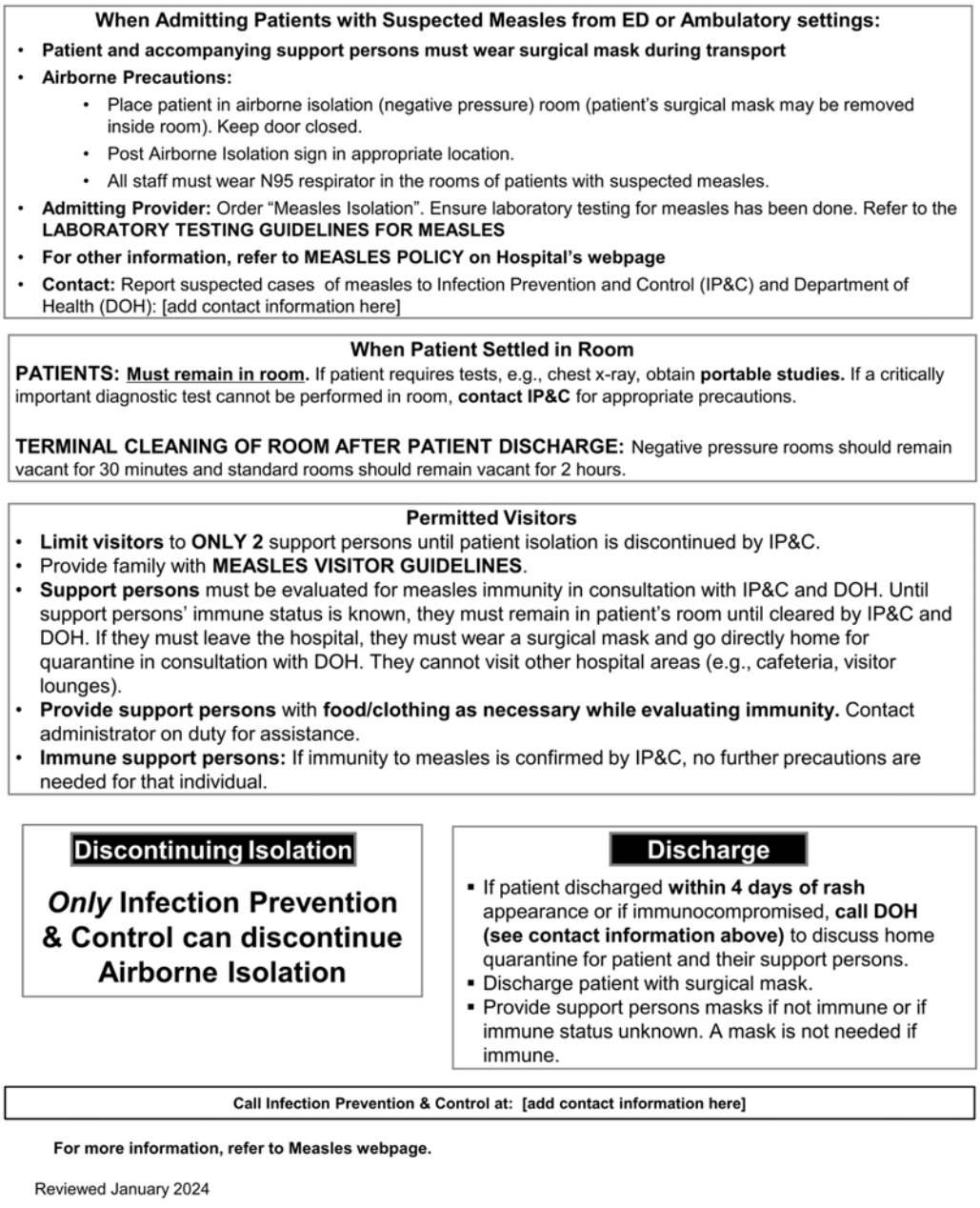

Figure 2. Hospitalized patients with suspected or confirmed measles. This algorithm describes appropriate isolation for and visitation to inpatients with measles.

with measles must be placed in Airborne Isolation with negative pressure while infectious. However, as exemplified by the two cases, isolation of patients with measles can be delayed, thereby requiring identification of numerous exposed patients, staff, and visitors, potentially in multiple locations. The limited number of negative pressure rooms can further delay isolation as these rooms are usually occupied by other patients who must be relocated.

To identify exposed individuals, we first determine the exposure window(s) and exposure location(s), ie, **when** the patient was infectious, based on rash onset, and **where** the patient was while infectious, eg, the ED waiting area, hospital units, or procedure areas. The exposure window includes the arrival time through discharge plus two hours or until placement in a negative pressure room plus two hours. The rationale for extending the exposure window for two hours is that viable measles virus can remain airborne and infectious for as long as two hours after the infectious individual has left the area or been placed in Airborne isolation.[1,12]

Identifying exposed patients

To identify patients and staff exposed to high-consequence infectious diseases, including measles, our healthcare system created a comprehensive clinical trace tool in our electronic medical record (EMR), Epic. Using this tool, we identify patients registered in the ED, hospitalized on inpatient units, or present in procedure areas when the infectious case was present. Elements of the contact trace include the time of arrival and discharge/ transfer, demographic information and bed locations. Because of the frequency of patient movement and use of overflow spaces in EDs, the trace must be reviewed and revised to accurately identify exposed patients. Once confirmed, exposed patients are added to

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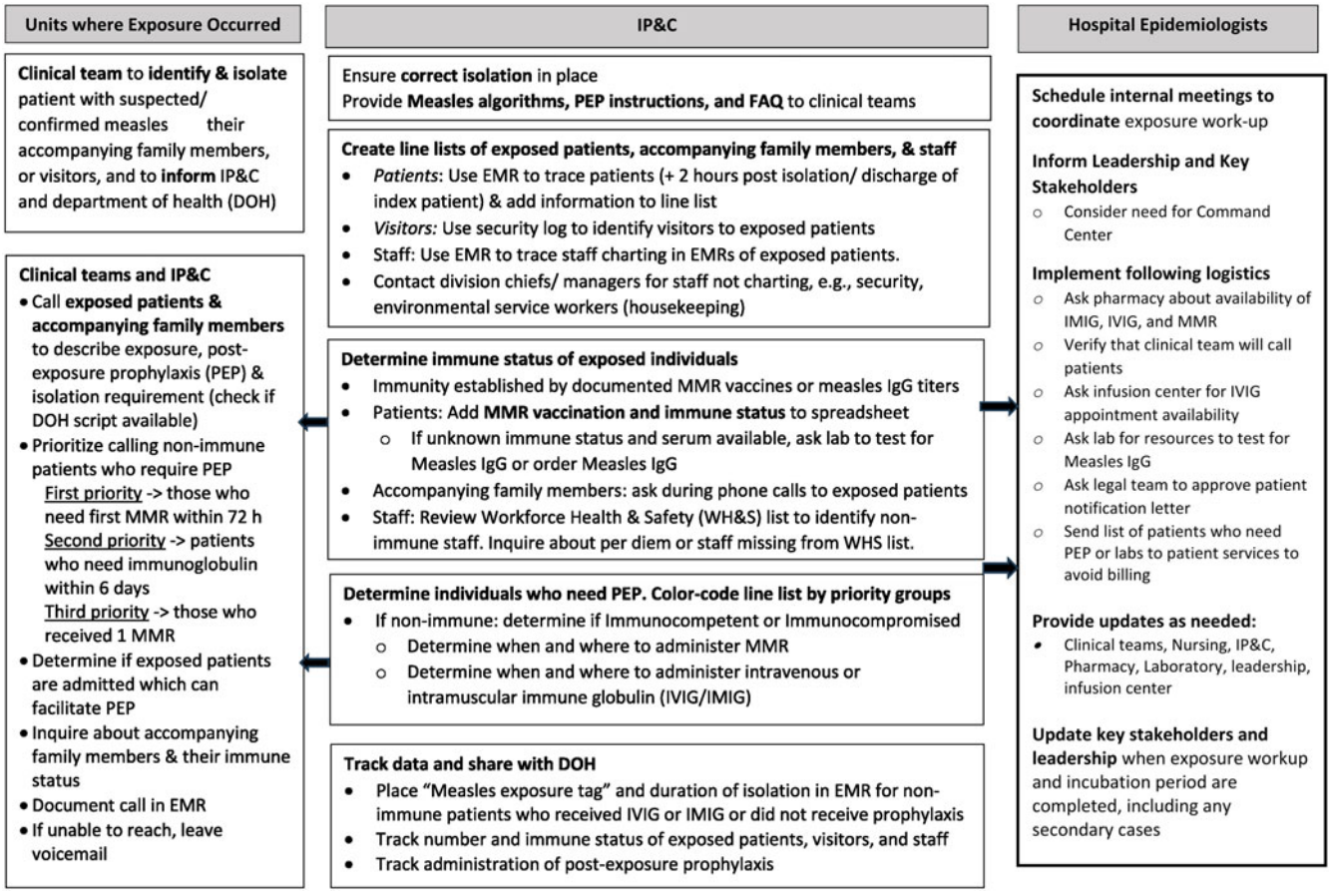

Figure 3. Measles exposure workflow. This document details the roles of key stakeholders and prioritizes the steps in the exposure investigation. Such a document is invaluable as a given healthcare facility may have very infrequent measles exposures.

the line list which contains relevant demographic and contact information pulled from the EMR (Supplemental Figure 2).

By the time the index case has been identified, many exposed patients have been discharged and must be contacted by phone. The exposure management team share the responsibility of contacting these patients. However, patients and families may not answer their phones, so our voicemail messages provide a call-back number answered by staff knowledgeable about the exposure, PEP, and the infectious period. We also ask providers in our ambulatory care network to contact their exposed patients as clinic phone numbers are familiar to families, and they may be more likely to answer. Text messages have also been used in previous exposure investigations.

Identifying exposed staff

To identify exposed staff, we also perform a comprehensive clinical trace to identify staff who accessed the charts of exposed patients during the exposure window. However, this list must also be revised to remove staff who did not enter the area, eg, pharmacy staff, and add exposed staff who did not access patients' chart, eg, security staff, EVS, medical students or other team members on consulting services. We ask the unit leadership and managers of ancillary staff to provide a list of staff working on relevant units during the exposure window. As this task is time-consuming, we initiate these requests while awaiting measles test results. To determine the immunity of exposed staff, we review the staff list provided by WH&S and contact the management for agency nurses and vendors. Fortunately, very few members of our staff are non-immune to measles and even fewer have required PEP.

Identifying exposed family members and visitors

Identifying the visitors and accompanying family members of exposed patients is challenging (Table 1). Security maintains visitor logs for inpatients. However, our healthcare system does not maintain similar logs for individuals accompanying patients to ambulatory clinics or EDs although future efforts could use the EMR to collect this information. At present, we identify those who accompanied patients to non-inpatient settings when we contact exposed patients. If accompanying individuals are not in our healthcare system, it can be difficult to accurately determine if they are immune to measles or immunocompromised. Many adults do not have documentation of their vaccinations although we do interrogate the city's vaccination registry, and the health department solicits vaccination records from other jurisdictions. Despite these limitations, we have identified infants < 6 months of age and pregnant individuals who accompanied their family members and subsequently required PEP. As further outreach, IP&C provides administrative resources to send letters (English/ Spanish) to all exposed patients and their families using a template from the health department. However, these letters may be received when it is too late to receive PEP. Another option, employed by the health department during a mumps outbreak, is the use of social media

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Table 2. Recommendations for measles post-exposure prophylaxis[15] and duration of home quarantine or airborne isolation[1]

Immune Status by Age	Timing and Type of PEP	Duration of Home Quarantine or Airborne Isolation
Measles immune (all ages) *2 documented MMR doses **OR*** *Measles IgG positive **OR*** *Born before 1957* [2,3]	No PEP	None
Measles non-immune		
<6 m old	Within 6 d: IMIG	7 to 28 d after exposure - home quarantine **or** airborne isolation in healthcare facility
	After 6 d: No PEP	7 to 21 d after exposure - home quarantine **or** airborne isolation in healthcare facility
6–11 mo old	Within 72 h: MMR[4]	None
	>72 h to 6 d: IMIG	7 to 28 d after exposure - home quarantine **or** airborne isolation in healthcare facility
	After 6 d: No PEP	7 to 21 d after exposure - home quarantine **or** airborne isolation in healthcare facility
≥12 m old and ***no MMR** doses*	Within 72 h: MMR	None
	> 72 h: No PEP	7 to 21 d after exposure - home quarantine **or** airborne isolation in healthcare facility Provide MMR(V) after home quarantine
≥12 mo old and ***1 MMR** dose*	Within 72 h: MMR	None
	> 72 h: No PEP	None Provide MMR(V) as per routine immunization schedule
*Pregnant and **IgG negative***	Within 6 d of exposure: IVIG	7 to 28 d after exposure - home quarantine **or** airborne isolation in healthcare facility
	After 6 d: No PEP	7 to 21 d after exposure - home quarantine **or** airborne isolation in healthcare facility
Severely Immunocompromised, regardless of MMR or measle IgG history[5]	Within 6 d of exposure If < 12 mo: IMIG If ≥ 12 mo: IVIG	7 to 28 d after exposure - home quarantine **or** airborne isolation in healthcare facility
	After 6 d: No PEP	7 to 21 d after exposure - home quarantine **or** airborne isolation in healthcare facility
Unknown immunity Unsure of past MMR or Measles IgG		
Pregnant	Obtain Measles IgG:[6] If positive measles IgG: No PEP If negative **and** within 6 d of exposure: IVIG	If IgG positive: None 7 to 28 d after exposure - home quarantine **or** airborne isolation in healthcare facility Provide MMR(V) 8 mo after receipt of IVIG
Non-pregnant, non-immunocompromised adults or children ≥12 mo	Within 72 h: MMR	None
	> 72 h, obtain measles IgG: No PEP	If IgG positive: None If IgG negative: 7 to 21 d after exposure - home quarantine **or** airborne isolation in healthcare facility

Adapted from Ref 15 https://www.nyc.gov/assets/doh/downloads/pdf/imm/pep-measles-providers.pdf.
[1]Abbreviations used in Table: PEP, post-exposure prophylaxis; IMIG, intramuscular immune globulin; IVIG, intravenous immune globulin.
[2]Immunocompromised individuals before 1957 may still require PEP.
[3]Birth prior to 1957 is not used as immune criteria for healthcare personnel.
[4]Will not count towards routine childhood immunization schedule.
[5]Discuss individualized plan with primary subspecialty providers.
[6]Discuss need for rapid result with laboratory.

and news outlets to disseminate information about outbreaks and vaccination.[13]

Providing post-exposure prophylaxis

PEP for measles is highly effective.[14] In a study performed in New York City in 2013, 3409 exposed individuals were identified of whom 44 received MMR and 77 received immunoglobulin (IG). The effectiveness of MMR PEP was 83.4% (95% confidence interval [CI_{95}] 34.4%, 95.8%) and the effectiveness of IG PEP was 100% (CI_{95} 56.2%, 99.8%) as no one receiving IG PEP developed measles.

In the infant case described above, patients, staff, and visitors in the ED and inpatient unit were exposed over several days. This made providing timely PEP very challenging, particularly for the earlier exposures. Provision of PEP is based on age and immune status and subsequently informs the duration of home quarantine or Airborne Isolation; the incubation period for those receiving

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intramuscular IG (IMIG) or intravenous IG (IVIG) is prolonged to 28 days (Table 2).[15] In efforts to provide PEP to as many exposed individuals as feasible, we prioritize PEP based on the time frame for PEP administration (Table 2, Figure 3), color coding three PEP priority groups on the line list (Table 1, Supplemental Figure 2). IMIG is administered to infants in our pediatric EDs as IMIG is not readily available in pediatric practices. When scheduling IVIG administration for immunocompromised patients and non-immune pregnant people, infusion center staff should be reassured that the patient receiving IVIG is not yet infectious. In our experience, while most families of exposed children and most exposed adults agree to receive PEP, a minority do not return to receive their PEP.

Another challenge is payment for PEP and for testing. Our healthcare system will exempt patients from payment, but IP&C must provide the names of individuals at the time the services are provided so families do not receive a bill.

Tasks during incubation period for exposed individuals

Exposed individuals who require Airborne Isolation during their incubation period receive the infection tag 'measles exposed' in our EMR and the dates they require isolation should they remain hospitalized, return to the ED, or require an admission. Those who receive MMR PEP do not require isolation. One challenge is managing exposed patients with complex comorbid conditions who require visits that cannot be performed virtually or tests or procedures that cannot be postponed in an area without Airborne Isolation rooms, eg, ambulatory clinics or phlebotomy units (Table 1). On a case-by-case basis, these care activities are allowed during the incubation period if the patient and their accompanying family member are asymptomatic as confirmed by the treating provider the night prior to the appointment

Finally, each exposure investigation is different and may pose unique challenges. We have found that having a "lessons learned" follow-up meeting among key stakeholders can be very useful to identify what went well and what could be improved, including strategizing together about potential solutions for unaddressed challenges.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/ice.2025.49

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