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Multiple Measles Transmission Events Associated with a Single Traveler Arriving in the United States, May 2025

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Abstract

Objective: Travelers who fly on commercial aircraft while infectious with measles are reported to CDC by health departments. CDC contacts airlines to collect information on potentially

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exposed travelers. Traveler locating information is shared with health departments to facilitate aircraft contact investigations. In May 2025, CDC was notified of a traveler who flew from Europe to Colorado while infectious with measles, transited through Denver International Airport, then flew from Colorado to North Dakota. This report describes details of the subsequent contact investigations, environmental assessment, and laboratory testing results.

Methods: CDC laboratories conducted testing on a majority of case samples. Data from the CDC laboratory, CDC's Port Health Activity Reporting System, and health department investigations were analyzed to describe the index case, contacts, test results, and travel details. Flight records and visual inspection were used to describe relative locations of index and secondary case-patients at Denver International Airport.

Results: The index case was in an unvaccinated adult. Aircraft contact investigations identified 135 exposed domestic travelers. Fifteen secondary cases were identified among people exposed during the international (5) and domestic (3) flights, and at the airport (7). Two tertiary case-patients were also identified. Five of the secondary case-patients had at least one documented prior measles vaccination.

Conclusion: Measles transmission may occur during travel. Measles vaccination is recommended prior to international travel for all travelers aged 6 months or older. Travelers with fever and other overt signs of transmissible illness, such as coughing or malaise, should be strongly encouraged to delay travel while symptomatic.

Keywords

Measles; air travel; transmission; border health; infectious

INTRODUCTION

Measles is one of the most transmissible viral diseases, spread via direct contact or airborne transmission. Vaccination with two doses of the measles-mumps-rubella (MMR) vaccine is 97% effective for preventing infections.¹ Although infrequent, measles transmission on aircraft is well documented.^{5,6,7,8} Over the past two decades the highest number of secondary measles cases identified from exposure to a single index case-patient on a single flight was five travelers on a flight from Malaysia to the U.S., all of whom were unvaccinated children.⁹ Secondary infections due to exposures in airports have also been documented.^{10,11,12} Secondary infections occurring on aircraft have been documented in both vaccinated and unvaccinated people.⁶ Despite a highly effective vaccine, infections can occur in vaccinated persons after exposure, particularly if the vaccinated person was exposed to a high level of infectious virus. Vaccinated people who contract measles generally have milder symptoms and fewer complications, and rarely transmit measles to other people.^{2,3,4}

The U.S. Centers for Disease Control and Prevention (CDC) works with airlines and U.S. health departments to initiate aircraft contact investigations (CIs) when travelers who flew while infectious with measles on domestic or U.S. inbound international flights are identified and CDC is notified within 21 days of the flight.¹³ The infectious period is defined as four days prior to onset of rash to four days after rash onset.² The defined contact zone for measles currently used for these aircraft CIs includes passengers sitting within two

rows of the ill traveler, any infant in arms seated anywhere on the plane, and any cabin crew who served the index case-patient. For aircraft with 50 or fewer passenger-capacity, or flights with unassigned seating, all passengers and crew are considered exposed. To identify exposed travelers, CDC requests a flight manifest from the airline(s) and then shares domestic travelers' contact information with health departments of jurisdiction where the travelers are currently residing via Epi-X, a secure data exchange platform. Exposed foreign travelers are also identified, and those travelers' countries of origin are notified and investigate using their country-specific contact investigation protocols. U.S. health departments receiving traveler contact information communicate with exposed travelers to notify them of the exposure, review history of vaccination or prior measles illness, recommend and help coordinate post-exposure prophylaxis (PEP) for eligible travelers, and provide information on measles symptoms and guidance to contact the health department if symptoms develop. The exact means of communicating with and interviewing exposed travelers varies by jurisdiction, but CDC requests health departments collect a minimum standardized set of variables for cases in which travel is reported. The window for effective PEP is three days after exposure for contacts eligible to receive the MMR vaccine, or six days for those considered at high risk for severe disease or complications (pregnant women, infants, and immunocompromised people) and for whom immunoglobulin is recommended.¹⁴ Health departments may follow up with susceptible exposed travelers during their incubation period to gather additional information, including identification of any secondary infections that develop. Data are reported back to CDC on a voluntary basis and maintained in CDC's Port Health Activity Reporting System (PHARS), an electronic system used to store information on activities conducted at CDC's 20 port health stations.

In May 2025, CDC was notified of a traveler who flew while infectious with measles on an international flight from Europe to Colorado, transited through the Denver International Airport before and after an overnight hotel stay, and then flew on a domestic flight from Colorado to North Dakota, exposing travelers on both flights, in airports, and potentially at the hotel. Given the rapid identification of multiple secondary case-patients on the international flight, the standard measles airplane CI zone, comprising 50 passengers and cabin crew, was expanded to include an additional 66 passengers who were seated in the same section as the index case-patient. For the domestic flight, because the passenger capacity size was less than 50 passengers, all travelers on the flight were included in the airplane CI zone (total of 40 passengers and crew).

This report describes in detail the resulting CI outcomes, including laboratory testing results for secondary and tertiary case-patients, and an environmental assessment.

METHODS

Information recorded in PHARS was extracted to describe the index case-patient, contacts, and travel details. Variables extracted from PHARS and included in the descriptive analysis were age, sex, vaccination status, exposure setting, time from exposure to contact notification, recommendations for PEP, and time to rash onset.

Environmental assessment included a calculation of wait times between boarding and departure based on flight schedules. FlightAware (<https://www.flightaware.com/live/flight/>) was used to determine scheduled boarding and flight departure times, arrival and departure gates, taxi time, and time from landing to gate. Time for boarding and deplaning was estimated from aircraft manuals for the affected aircraft.^{19,20} Total ground time was calculated by adding boarding time, taxi time, time from landing to gate, and deplaning time. Visual inspection of affected gates in the Denver International airport terminal, plane maps, and aircraft seating charts were used to determine proximity of contacts and secondary case-patients to the index case-patient.

Data were extracted from PHARS using Microsoft SQL Server Management Studio. Descriptive analyses to track case counts and calculate attack rate, mean, median, range, and percentages were completed using Microsoft SQL Server Management Studio and Microsoft Excel.

Due to the large number of secondary case-patients identified, CDC performed additional laboratory testing on specimens from identified cases which included N450 genotyping,¹⁵ whole genome sequencing,¹⁶ IgG avidity,¹⁷ and plaque reduction neutralization (PRN).¹⁸

This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy (see e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44).

RESULTS

Index case

The index measles case was in an unvaccinated adult exposed to measles prior to international travel in an ongoing outbreak in the United States. On his return trip, he traveled first on an international flight to Colorado, transited through the main terminal of Denver International Airport on the day of his arrival, stayed overnight at a hotel near the airport, then transited again through the airport the next day before taking a domestic flight to North Dakota. The health department which interviewed the index case-patient reported he had a subjective fever, persistent cough, coryza, and conjunctivitis during travel. His rash onset occurred two days after his return international flight and one day after his domestic flight. His subsequent nasopharyngeal (NP) swab sample (a reverse-transcription polymerase chain reaction (RT-PCR) test) was collected four days after rash onset and the test result was positive (Table 1).

Secondary cases and exposures on aircraft

A total of 135 U.S.-based travelers, representing a total of 14 U.S. health department jurisdictions, were seated in the defined primary and expanded contact zones of the two aircraft: 97 on the international flight to Denver and 38 on the domestic flight to North Dakota, and were considered to have been exposed. Eight secondary cases of measles were identified in these travelers: five in travelers on the international flight to Denver (attack rate 5%), and three in travelers on the domestic flight (attack rate 8%). On the international flight, four of the infected contacts were passengers seated in the primary contact zone; one

was a passenger in the expanded zone. No cases were identified among in-flight aircraft crew members (Figure 1).

The international flight's total ground time was approximately 76 minutes. The flight duration was 11 hours 23 minutes. The domestic flight's total ground time was approximately 36 minutes.²⁰ The flight duration was 1 hour 17 minutes; thus total passenger time on board the aircraft was approximately 1 hour 53 minutes.

Secondary cases and exposures in airports

Seven additional secondary cases among persons exposed at the Denver International Airport were identified. No additional secondary cases were identified at other transited airports or the hotel. The total number of people exposed in the airports or at the hotel could not be estimated.

One secondary case was in an employee in a public-facing business who was present in the main terminal on the index case-patient's day of arrival (Table 1). Six secondary cases were in travelers who departed from one end of a single airport concourse on the same day that the index case-patient departed from the same area (Figure 2). All six arrived within 43 minutes of the departure time of the index case-patient's flight (range 7-43 minutes, median 18 minutes), and departed from gates concentrated at one end of the concourse and located within 1500 feet of each other, sharing an area which included restrooms and a coffee shop (Figure 2). The majority of these gates were located in an area identified as serving regional jets, which opened in 2007. This area had undergone renovations since opening but was not included in the gate expansions that occurred nearby during 2020-2022 (personal communication with airport management).^{21,22}

Tertiary cases and household exposures

Two cases of tertiary transmission were identified in persons who were each exposed through non-household interactions with different secondary case-patients.

Demographics and reported symptoms of cases

Secondary measles cases occurred in two children and 13 adults, ranging in age from 1 to 59 years; eight (53%) were female and seven were male. The two tertiary case-patients were adults (1 male, 1 female, both aged 18-50 years) exposed to adult secondary case-patients. All resided in the U.S. at the time of diagnosis, and represented six jurisdictions, including one jurisdiction not represented in the aircraft contact zone exposures.

All 18 case-patients (the index, 15 secondary, two tertiary) exhibited rash, and 17/18 (94%) case-patients experienced fever or chills. Nine of 18 case-patients (the index, 7 secondary, one tertiary - 50%) exhibited cough, coryza, and conjunctivitis. Five case-patients, three unvaccinated and two with verbal report of prior vaccination, required hospitalization. The reported rash onset dates of the secondary case-patients ranged from 11 to 27 days post-exposure (median 14 days, IQR 13-17 days). The secondary case-patient whose rash onset was 27 days post-exposure was identified as having a pre-existing immunosuppressing condition and experienced first symptom onset (diarrhea) 18 days after exposure. The rash

onset dates of the two tertiary case-patients were between 9- and 14-days post-exposure (Table 1).

Immune history of cases and contacts

Immune history was obtained for 117 (87%) of the 135 travelers and crew exposed on aircraft, including all those diagnosed with measles, as well as the two tertiary case-patients. Among all exposed travelers with provided immune history, 101/117 (86%) reported either vaccination or birth before 1957 (therefore presumed immune through prior measles disease): 49/117 (42%) provided documentation of vaccination with at least one dose of measles-containing vaccine at the time of exposure, 47/117 (40%) provided verbal report of prior vaccination with no available documentation, and 5/117 (4%) reported birth before 1957. No exposed persons on either aircraft were recommended to receive PEP as notification to CDC of the infectious index case-patient did not occur until six days (domestic flight) or seven days (international flight) after exposure, and earliest receipt of flight manifests identifying exposed passengers and crew occurred seven days after exposure.

Among the 15 secondary case-patients, 10/15 (67%) reported vaccination: 5/15 (33%) had documentation of prior vaccination, and 5/15 (33%) provided verbal report of prior vaccination. Five of 15 (33%) were unvaccinated (no verbal report or vaccine documentation provided). Of the five secondary case-patients with documentation, four had received two doses of measles-containing vaccine (all more than ten years prior to this exposure), and the fifth, a child residing in the U.S. who was exposed on the domestic flight, had only received a single dose due to age being younger than the recommended age for a second dose. Of the two tertiary case-patients, one had documentation of two doses of measles-containing vaccine and was exposed to a secondary case-patient with a verbal report of prior vaccination; the other was unvaccinated and was exposed to an unvaccinated secondary case-patient (Table 1).

Laboratory testing results of cases

Samples collected for all 17 secondary and tertiary case-patients tested positive by RT-PCR. Throat or NP swabs for RT-PCR were collected for 16 of 17 case-patients, urine samples for PCR were collected for 7 of 17 case-patients, and both NP/throat swabs and urine samples for PCR were collected for 7 of 17 case-patients. Of NP/throat swabs, 14 of 16 (88%) were positive, and 7 of 8 (88%) urine samples were positive. Notably, for the two secondary case-patients for whom NP swabs were negative, urine samples were positive, and for the secondary case-patient for whom the urine sample was negative the NP swab was positive. The three secondary case-patients with discordant RT-PCR sample results (*i.e.* one negative, one positive) were reported as vaccinated against measles. Eight of 17 case-patients provided serum for IgM testing; one sample was untestable, but the 7 samples tested were all IgM positive.

The time from rash onset to sample collection ranged from -1 to 24 days (median 2 days, IQR 1-2 days). The secondary case-patient whose specimens were collected one day prior to rash onset tested negative by RT-PCR on NP swab but positive on urine (no serum collected

for IgM), and the secondary case-patient whose specimens were collected 24 days after rash onset tested positive on urine RT-PCR and IgM serology (no NP swab collected).

Additional genome testing was conducted on 11 samples. Testing of samples from the index case-patient and eight (53%) secondary case-patients (three from the international flight, three from the airport concourse, two from the domestic flight) identified the measles viral genotype as D8 with a distinct sequence ID²³ of 9171; samples of two additional secondary case-patients (one from the international flight and one from the airport concourse) were unable to be genotyped due to low copy number most likely attributable to their vaccination status (2 MMR doses).

Whole genome sequencing (WGS) was performed and complete genome assembly of 7 of 11 samples was conducted. WGS results indicated that viral sequences from the index measles case-patient and identified secondary case-patients were related. Additionally, WGS analysis demonstrated extremely limited and antigenically insignificant differences compared to current and previously circulating measles strains in the United States. The results demonstrated IgG positivity with both high IgG avidity and high plaque reduction neutralization (PRN) titers, which is consistent with secondary vaccine failure in the vaccinated cases (Table 2).

DISCUSSION

This case of an unvaccinated traveler who flew commercially while infectious and symptomatic with measles, transmitting the virus to 15 others during travel with subsequent community transmission, and exposing travelers from at least 15 different U.S. jurisdictions, highlights the continued importance of monitoring and tracking measles exposures during travel to quickly identify and mitigate spread. All but one of the secondary case-patients exposed during a flight were identified using the contact zone currently defined in CDC protocols for measles aircraft CIs. Given how contagious the measles virus is, missing a single secondary case of disease may not be acceptable. Expanding the contact zone in flights with multiple primary cases or multiple secondary cases may increase identification of additional secondary and tertiary cases. Approaches such as those currently used by the United Kingdom (notification of all passengers and crew on an aircraft in which an infectious traveler was present) or Canada (public notification when any traveler is identified who was infectious during a flight), could also be considered to broaden notifications beyond the aircraft contact zone currently used in the U.S.^{24,25}

The substantial number of secondary cases of disease among travelers and others exposed in the airport in this case emphasizes the need for good ventilation and airflow through the terminals, especially in older, smaller or more confined areas.²⁶ Due to high air exchange rates (typically 20-30 times an hour) when an aircraft's ventilation system is on, transmission of airborne pathogens is less likely on commercial passenger aircraft than in buildings (e.g., airports).²⁷ However, during boarding and deplaning, when there is closer contact between travelers both in the jet bridge and in aircraft aisles, the aircraft ventilation system air exchange is typically turned off to conserve fuel, and the aircraft relies on ground ventilation that is much less efficient. A high degree of infectiousness of the index

case-patient, a reported cough, and time spent in shared airspaces likely contributed to large number of secondary cases of disease among those exposed. Infectiousness likely peaks during late prodrome, prior to the development of neutralizing antibodies (heralded by the maculopapular rash), which was the time of the international and domestic flights for the index case-patient.²⁸ Delay in measles diagnosis in an index case-patient until several days after the flight is not an uncommon occurrence.⁵ PEP is only effective if administered within three to six days after exposure. The delay in diagnosis and subsequent delay in CDC notification for this index case-patient meant that notification of exposed passengers or crew occurred beyond the window for effective PEP. Test results indicated a secondary vaccine failure in three of the four secondary case-patients with documented MMR vaccines, which is known to occur in a small percentage of the vaccinated population.²⁹ Generally, measles vaccination is considered to provide robust protection against all wild-type measles viruses, and limited mutations detected by WGS suggest that viral mutations do not account for the large number of secondary cases of disease or high proportion of cases among previously vaccinated people.³⁰ The low number of detected tertiary cases may be due to lower infectiousness of people with secondary vaccine failure, implementation of public health measures to prevent spread to unvaccinated close contacts (e.g., PEP, quarantine), or pre-existing immunity among tertiary contacts, and highlights the importance of vaccination.³¹

All secondary case-patients and the two tertiary case-patients had positive RT-PCR test results, and the majority of secondary case-patients' positive laboratory results were identified through the use of multiple testing methods, including serology and both urine and NP/throat swab RT-PCR, which are all identified by CDC as preferred testing specimens.³² Measles virus can be detectable in the urine even when not detectable by NP swab, particularly when sample collection is several days after rash onset or in mild cases.^{33,34} WGS results indicated that viral sequences from the index case-patient and secondary case-patients were related, and consistent with current circulating virus strains.

This investigation entailed a large expenditure of resources at both the federal and state level. Ongoing economic evaluation of aircraft contact investigations in the U.S. is currently underway. This assessment will help determine the most cost-effective strategies for managing measles exposures on commercial aircraft in the future. This is important particularly in the current situation in which measles cases are rising in the U.S. and globally, and the U.S. faces impending loss of measles elimination status.

This report has several limitations. Information identifying aircraft passengers outside defined contact zones is not routinely provided by airlines, and aircraft passengers from international jurisdictions are investigated by their home country and not by the CDC, thus additional cases among aircraft passengers may have been missed, including among passengers seated outside the defined contact zones on the international flight, or who had departed the United States at the time the CI was conducted. CDC's measles case database was cross-referenced to identify potential missed flight-associated cases; additionally, as part of routine aircraft CI procedures, CDC notified public health authorities in destination countries for passengers who were non-U.S. residents. No additional cases were identified through these mechanisms. We were unable to identify all travelers present at the Denver International Airport during the exposure window, thus unable to gather vaccination status

on those unidentified travelers. Additionally, the index case-patient traversed two additional airports and stayed in a hotel for which no exposed traveler information was available. We were unable to determine vaccination status of all identified exposed travelers who did not develop measles disease, thereby limiting our ability to determine whether secondary infectiousness was more common among unvaccinated contacts. Vaccination status of many secondary case-patients was identified through verbal recall, which can be an unreliable or incorrect source of immunization information. Improved implementation of immunization information systems over time could potentially help to address this issue in the future. While three unvaccinated and two self-reported vaccinated secondary case-patients were reported hospitalized, other indicators of severity of symptoms were not available for the majority of secondary case-patients. The missing information related to vaccination makes it difficult to determine whether infection severity was worse in unvaccinated secondary case-patients as would be expected.³⁵

Public health implications

Measles transmission occurs during travel. Measles vaccination is recommended prior to international travel for all travelers ages 6 months or older and can reduce the risk of transmission and severe disease following exposure.^{36,37} Travelers with overt signs of transmissible illness, such as coughing, fever, and malaise, should be strongly encouraged to delay travel while symptomatic. Travelers with overt symptoms identified during travel should be separated from other travelers to the extent possible and encouraged to wear a mask, based on existing protocols in the jurisdiction alerted. Testing of different types of specimens (e.g. blood, NP, urine) by different laboratory methods (RT-PCR, IgM, IgG) based on vaccination status and time from rash onset can more completely identify true measles cases.

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Disclaimer.

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Data availability statement.

The data underlying this article cannot be shared publicly without permission of the jurisdictions that provided outcome data. The data may be shared on reasonable request to the corresponding author.

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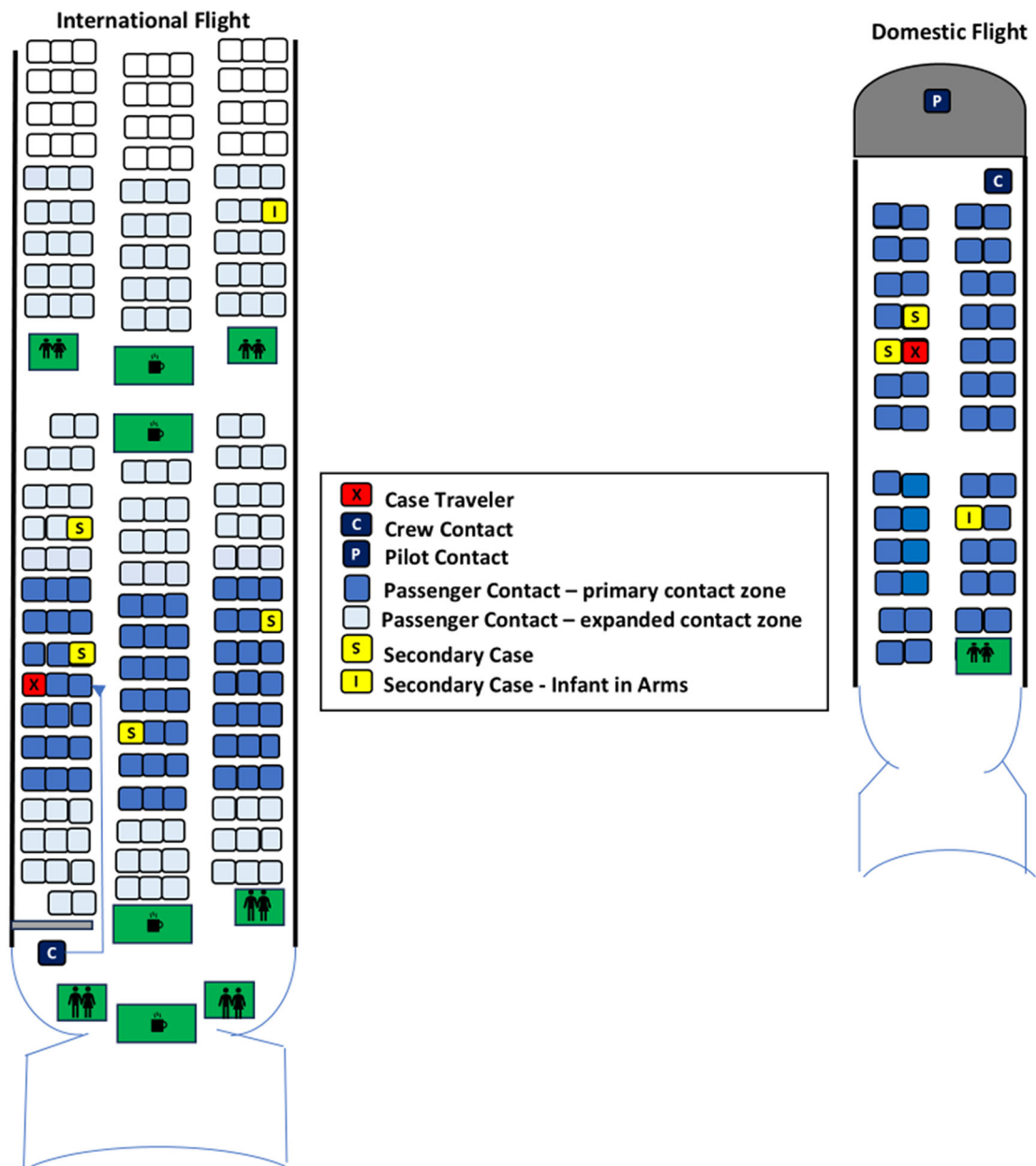


Figure 1 -
 Seat maps identifying index and secondary case-patient locations on international and domestic index case-traveler flights on which measles transmission occurred, United States, May 2025

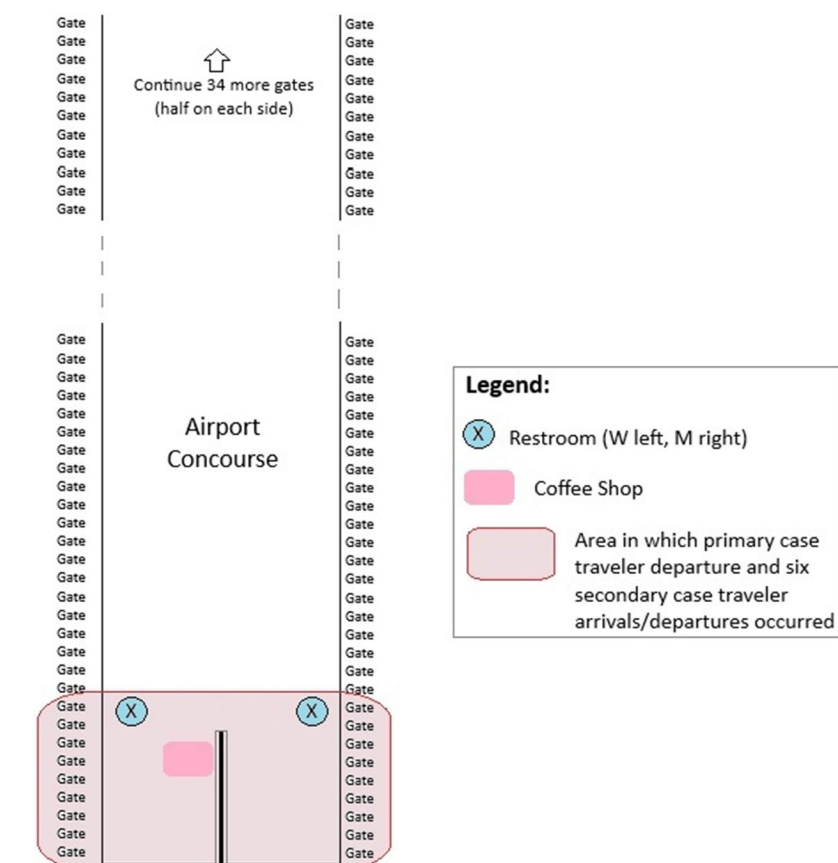


Figure 2 -
Map of domestic terminal concourse in Denver International Airport where index case-patient with measles and six travelers subsequently identified with measles disease were colocated, May 2025

Table 1 –

Characteristics of patients with measles who were part of a case cluster associated with a single infectious air traveler, United States, May 2025

Index/ Secondary/ Tertiary Case	Age (years)	Sex	Vaccinated at time of exposure?	Days exposure to rash onset	Symptoms include rash and fever?	Exposure setting	Exposure proximity to index case
Index	18-50	Male	No	NA – Index	Yes	NA – Index	NA – Index
Secondary	0-2	Male	No	12	Yes	international flight	infant-in-arms *
Secondary	18-50	Male	Yes [^]	13	Yes	international flight	within 2 rows
Secondary	18-50	Male	Yes [#]	18	Yes	international flight	within 2 rows
Secondary	18-50	Female	Yes [^]	13	Yes	international flight	within 2 rows
Secondary	18-50	Female	Yes [^]	16	Yes	international flight	within 5 rows
Secondary	18-50	Male	No	16	Yes	airport – concourse gate	unknown
Secondary	18-50	Female	Yes [^]	17	Yes	airport – concourse gate	unknown
Secondary	18-50	Male	No	25	Yes	airport – main terminal	unknown
Secondary	18-50	Male	No	11	Yes	airport – concourse gate	unknown
Secondary	18-50	Female	No	12	Yes	airport – concourse gate	unknown
Secondary	>50	Female	Yes [#]	14	Yes	airport – concourse gate	unknown
Secondary	>50	Female	Yes [#]	27	Yes	airport – concourse gate	unknown
Secondary	18-50	Male	Yes [#]	14	Yes	domestic flight	within 1 row
Secondary	0-2	Female	Yes [^]	13	Yes	domestic flight	infant-in-arms *
Secondary	>50	Female	Yes [#]	17	No – rash only	domestic flight	same row
Tertiary	18-50	Female	Yes [^]	9-14	Yes	vaccinated [#] secondary case	NA – Tertiary
Tertiary	18-50	Male	No	9-13	Yes	unvaccinated secondary case	NA – Tertiary

[^] documented vaccination

[#] verbal traveler recall of vaccination only

* infants-in-arms may have an identified seat location anywhere within the aircraft – but have high likelihood of mobility during the flight

NA – not applicable

Table 2 -

Genotyping, Whole Genome Sequencing, and Serology Laboratory Results of cases with measles who were part of a case cluster associated with a single infectious air traveler, United States, May 2025

Strain Name	DSId	Exposure setting	Rash onset date	Complete WGS Assembly	Serology	Immunization History
MVs/North Dakota.USA/20.25/3	D8-9171	Index case	5/15/2025	Yes		Unvaccinated
MVs/Colorado.USA/22.25	D8-9171	International flight	5/25/2025	Yes		Unvaccinated
MVs/Colorado.USA/22.25/2	D8-9171	Airport – concourse gate	5/27/2025	Yes		Unvaccinated
MVs/Colorado.USA/22.25/3	D8-9171	International flight	5/31/2025	No	IgG+, High Avidity, High PRN titer	2 MMR
Unable to sequence	NA	Airport – concourse gate	5/29/2025	No	IgG+, High Avidity, High PRN titer	2 MMR
Unable to sequence	NA	International flight	5/25/2025	No		2 MMR
MVs/Colorado.USA/22.25/4	D8-9171	Airport – concourse gate	5/30/2025	Yes	IgG+, High Avidity, High PRN titer	Unvaccinated
MVs/California.USA/22.25	D8-9171	International flight	5/25/2025	No		2 MMR
MVs/Minnesota.USA/22.25/2	D8-9171	Domestic flight	5/28/2025	Yes		Unknown
MVs/South Dakota.USA/22.25	D8-9171	Airport – concourse gate	5/28/2025	Yes		Unvaccinated
MVs/New Mexico.USA/22.25	D8-9171	Domestic flight	5/27/2025	Yes		1 MMR

Trend: extremely limited and likely antigenically insignificant divergence of sequences

Abbreviations:

DSId – Distinct Sequence Identifier

WGS – Whole Genome Sequencing

PRN – Plaque Reduction Neutralization

MMR – Measles, Mumps, Rubella vaccine

NA – Not Applicable