Why Measles Matters

Division of Immunization Services Webinar
May 22, 2014

Gregory S Wallace, MD, MS, MPH
Lead, Measles/Mumps/Rubella/Polio Team
Epidemiology Branch, Division of Viral Diseases
National Center for Immunization and Respiratory Diseases
Centers for Disease Control and Prevention
What is Measles

• Febrile rash illness

• Most contagious of the vaccine preventable diseases

• Highly effective vaccine part of the routine immunization schedule
Clinical Presentation

• Rash ~14 days after exposure (range 7-21 days)

• Fever (up to 105°F)

• Cough, Coryza, and/or Conjunctivitis
Measles Rash

• Follows prodrome lasting 2-4 days

• Prodrome may include Koplick Spots

• Erythematous maculopapular eruptions
  – Spreads from head to trunk to extremities
  – Initially blanching

• Fades in order of appearance
# Measles Complications

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percent reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea</td>
<td>8</td>
</tr>
<tr>
<td>Otitis media</td>
<td>7-9</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>1-6</td>
</tr>
<tr>
<td>Encephalitis</td>
<td>0.05-0.1</td>
</tr>
<tr>
<td>Death</td>
<td>0.1-0.2 (2-15 in developing countries)</td>
</tr>
<tr>
<td>Subacute Sclerosing Panencephalitis (SSPE)</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Global Burden of Measles

• Prior to Vaccine: 5-8 million deaths/year

• 77% decrease in incidence from 2000 to 2012

• 78% decrease in deaths from 2000 to 2012 (90% since 1985)
  – 122,000 deaths in 2012 (~14 deaths/hour)

• Remains a leading cause of Vaccine Preventable Deaths in young children
  – Most deaths in children under 5 years old
Measles Disease Incidence by WHO Region

FIGURE. Reported measles incidence per million population, by World Health Organization region and worldwide, 2000–2011

Measles Case Distribution by Month and WHO Regions, 2008-2014

This is surveillance data, hence for the last month, the data may be incomplete.

SEAR  India is not included in this graph.

As of 27 May 2013, South Sudan has reassigned to the Africa region (AFR) from the Eastern Mediterranean region (EMR).
Measles Outbreak, France, 2008-2011 (n>20,000)

Measles Outbreak, Quebec, Canada, 2011 (n=725)

Measles cases by month of rash onset
Philippines, 2009–2014*

*as of March 15, 2014
Source: National Epidemiology Center
Global transmission patterns of measles viruses from the Philippines, 2014
US Annual Disease Burden Prior to Vaccine

- 3-4 million estimated and ~ 500,000 reported cases
- 48,000 hospitalizations
- 4,000 encephalitis cases
- 450-500 deaths
Measles Cases, United States, 1962-2014*

*2014 case count preliminary as of May 16
Reported Measles Incidence
United States, 1992-2014*

*2014 case count preliminary as of May 16
Measles, United States, 2001-2014*
Age Specific Incidence

*2014 case count preliminary as of May 16
Measles, United States, 2001-2014*

Importations by WHO Region

- Unknown
- Western Pacific (WPR)
- South East Asian (SEAR)
- European (EUR)
- Eastern Mediterranean (EMR)
- African (AFR)
- American (AMR)

*2014 case count preliminary as of May 16
### Measles, United States, Jan – May 16, 2014

#### Source of Importations (N=45)

<table>
<thead>
<tr>
<th>WHO Region</th>
<th># of cases</th>
<th>Countries of travel</th>
</tr>
</thead>
<tbody>
<tr>
<td>African</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Eastern Mediterranean</td>
<td>1</td>
<td>Pakistan</td>
</tr>
<tr>
<td>European</td>
<td>4</td>
<td>Dubai/Germany/London (1), Republic of Georgia (1), Netherlands (1), France/Belgium</td>
</tr>
<tr>
<td>Americas</td>
<td>4</td>
<td>Brazil (1), Canada (2), Chile (1)</td>
</tr>
<tr>
<td>South-East Asia</td>
<td>7</td>
<td>India (7)</td>
</tr>
<tr>
<td>Western Pacific</td>
<td>29</td>
<td>China (2), Philippines (22), Singapore (1), Saipan (1), Vietnam (1), SE Asia/Philippines (1), Malaysia/Micronesia (1)</td>
</tr>
</tbody>
</table>
Most Measles Cases Result in Limited Transmission

2014: 80% with 1 or 2 chains of transmission, 4% with 10 or more
*2014 case count preliminary as of May 16
## Measles Outbreaks with 20 or more Cases, United States, 2001-2014*

<table>
<thead>
<tr>
<th>Year</th>
<th>Outbreak Name</th>
<th>State</th>
<th>Cases #</th>
<th>Import Status</th>
<th>Genotype</th>
<th>Setting</th>
<th>1st &amp; last rash onsets</th>
<th>Duration</th>
<th>Median Age</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Brooklyn</td>
<td>NYC</td>
<td>58</td>
<td>Imported (UK)</td>
<td>D8</td>
<td>Household/</td>
<td>3/13/2013 – 6/9/2013</td>
<td>13 weeks</td>
<td>10 y (early)</td>
<td>0 mos – 32 y</td>
</tr>
<tr>
<td>2005</td>
<td>Tippecanoe County</td>
<td>IN</td>
<td>34</td>
<td>Imported (Romania)</td>
<td>D4</td>
<td>Church/household</td>
<td>5/16/2005 - 6/24/2005</td>
<td>6 weeks</td>
<td>12 y</td>
<td>9 mo - 49 y</td>
</tr>
<tr>
<td>2008</td>
<td>DuPage/Cook County</td>
<td>IL</td>
<td>30</td>
<td>Imported-virus</td>
<td>D4</td>
<td>Homeschool</td>
<td>5/17/2008 - 7/3/2008</td>
<td>7 weeks</td>
<td>10 y</td>
<td>8 mo - 43 y</td>
</tr>
<tr>
<td>2013</td>
<td>Stokes/Orange County</td>
<td>NC</td>
<td>23</td>
<td>Imported (India)</td>
<td>D8</td>
<td>Community</td>
<td>4/5/2013 – 5/7/2013</td>
<td>5 weeks</td>
<td>14 y</td>
<td>12 mo - 59 y</td>
</tr>
<tr>
<td>2013</td>
<td>Tarrant/Denton County</td>
<td>TX</td>
<td>21</td>
<td>Imported (Indonesia)</td>
<td>D9</td>
<td>Church</td>
<td>7/21/2013 – 8/21/2013</td>
<td>5 weeks</td>
<td>11 y</td>
<td>4 mos – 44 y</td>
</tr>
<tr>
<td>2011</td>
<td>Hennepin County</td>
<td>MN</td>
<td>21</td>
<td>Imported (Kenya)</td>
<td>B3</td>
<td>Shelter</td>
<td>2/15/2011 - 4/24/2011</td>
<td>10 weeks</td>
<td>23 m</td>
<td>3 mo - 51 y</td>
</tr>
<tr>
<td>2008</td>
<td>Brooklyn/Kings County</td>
<td>NYC</td>
<td>21</td>
<td>Imported (Israel, Belgium)</td>
<td>D4</td>
<td>Community</td>
<td>2/17/2008 - 4/25/2008</td>
<td>10 weeks</td>
<td>15 m</td>
<td>5 mo - 11 y</td>
</tr>
<tr>
<td>2014</td>
<td>Manhattan</td>
<td>NYC</td>
<td>20</td>
<td>Imported-virus</td>
<td>B3</td>
<td>Community</td>
<td>2/16/2014 – 3/24/2014</td>
<td>5 weeks</td>
<td>23 y</td>
<td>3 mo – 36 y</td>
</tr>
</tbody>
</table>

*as of May 16, 2014
Measles outbreak response has a high economic burden in the U.S.

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Number of cases (outbreaks)</th>
<th>Estimated public health cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>US</td>
<td>107 (16)</td>
<td>$2.7-5.3M</td>
</tr>
<tr>
<td>2011</td>
<td>Utah</td>
<td>13 (2)</td>
<td>&gt;$330,000</td>
</tr>
<tr>
<td>2008</td>
<td>California</td>
<td>12 (1)</td>
<td>$125,000</td>
</tr>
<tr>
<td>2008</td>
<td>Arizona</td>
<td>14 (1)</td>
<td>$800,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(limited to cost for 2 hospitals to respond to 7 cases in their facilities)</td>
</tr>
<tr>
<td>2005</td>
<td>Indiana</td>
<td>34 (1)</td>
<td>$168,000</td>
</tr>
<tr>
<td>2004</td>
<td>Iowa</td>
<td>1</td>
<td>$142,000</td>
</tr>
</tbody>
</table>

*Public health and health care costs expended to control the spread of measles
Measles, U.S., 1997-2014*
Cumulative Number by Month of Rash Onset

*As of May 16, 2014
Measles U.S. 2014*

- 216 cases reported from 15 states including 15 outbreaks
  - 45 importations
    - 22 from the Philippines
    - 38 (85%) US residents
  - 96% cases import-associated
  - 38 cases (17%) hospitalized

- Cases in US residents (N=207)
  - 63% unvaccinated
  - 25% unknown vaccination status (90% of those adults)
  - 12% vaccinated (including 8% with 2 or more doses)
  - Among unvaccinated
    - 83% were personal belief exemptors
    - 6% unvaccinated travelers age 6-15 mos
    - 7% too young to be vaccinated

* Provisional reports to CDC through May 16, 2014
Measles Vaccine

• Available as Measles, Mumps, Rubella (MMR) in the U.S.

• Licensed in 1963 in the U.S.

• Combination MMR vaccine licensed in 1971

• Vaccine Effectiveness
  – 1-dose: ~93%
  – 2-dose: ~97%
ACIP Measles Vaccine Recommendation History

1963: Age 9 mos

1965: Age 12 mos

1967: Age 15 mos

1989: 2 doses (as MMR) @ age 15 mos & 4-6 yrs

1994: 2 doses (12-15 mos & 4-6 yrs)
Travel Recommendations for Measles

• Persons aged $\geq 12$ months should receive 2 doses*
  – Includes providing a $2^{nd}$ dose to children prior to age 4-6 yrs
  – Includes adults** who have only received one routine dose in the past

• Children aged 6-11 months should receive 1 dose
  – If vaccinated at age 6-11 months, still need 2 subsequent doses at age $\geq 12$ months

* 2nd dose of MMR should be administered at least 28 days after the 1st dose
** Born in 1957 or later
Keys to Measles Prevention, Diagnosis, & Response

- Vaccine
  - Vaccine Rates
  - VE
- Diagnostics
  - Differential Diagnosis
  - Hx & PE
  - Lab testing
- Case Response
  - Reporting
  - Contact Investigation
  - Presumptive evidence of immunity
  - Isolation and Quarantine
  - Post Exposure Prophylaxis
MMR Vaccination Coverage
National Immunization Survey, U.S.

Coverage (%)

MMR 1+ (19-35 mo)    MMR 2+ (13-17 yr)

90

Diagnosing Measles

• Consider measles in differential diagnosis of febrile rash illness
  – e.g. Kawasaki’s, Dengue

• Travel History or Exposure to Recent Travelers

• Documented Vaccine History

• Lab testing
  – Serology for IgM
  – Viral specimen (nasopharyngeal, oropharyngeal, or nasal swab) for PCR (and genotyping)
Public Health Response (for confirmed and suspect cases)

• Respiratory isolation of cases
  – Infectious period 4 days prior through 4 days after date of rash onset

• Report to Health Department
  – Immediately notifiable to CDC (within 24 hours)
  – Contact CDC Quarantine Station if relevant travel
  – Enhanced Surveillance

• Contact investigation
Contact Investigation for Exposure to Measles

• Persons exposed during cases infectious period
  – Includes exposure to area 2 hours after case left

• Establish presumptive evidence of immunity for contacts

• Quarantine of contacts without presumptive evidence of immunity (through 21 days after exposure)

• Postexposure prophylaxis (PEP)
  – Vaccine or Immune globulin (IG)
## Presumptive Evidence of Immunity for Measles

<table>
<thead>
<tr>
<th>Routine</th>
<th>Students at post-high school educational institutions</th>
<th>Health-care personnel</th>
<th>International travelers</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) <strong>Documentation of age-appropriate vaccination</strong> with a live measles virus-containing vaccine:</td>
<td>(1) <strong>Documentation of vaccination with 2 doses of live measles virus-containing vaccine, or</strong></td>
<td>(1) <strong>Documentation of vaccination with 2 doses of live measles virus-containing vaccine, or</strong></td>
<td>(1) <strong>Documentation of age-appropriate vaccination</strong> with a live measles virus-containing vaccine:</td>
</tr>
<tr>
<td>– preschool-aged children: 1 dose</td>
<td>(2) Laboratory evidence of immunity, or</td>
<td>(2) Laboratory evidence of immunity, or</td>
<td>– infants aged 6–11 months: 1 dose</td>
</tr>
<tr>
<td>– school-aged children (grades K-12): 2 doses</td>
<td>(3) Laboratory confirmation of disease, or</td>
<td>(3) Laboratory confirmation of disease, or</td>
<td>– persons aged ≥12 months: 2 doses, or</td>
</tr>
<tr>
<td>– adults not at high risk: 1 dose, or</td>
<td>(4) Born before 1957</td>
<td>(4) Born before 1957 - should consider 2 doses</td>
<td>(2) Laboratory evidence of immunity, or</td>
</tr>
<tr>
<td>(2) Laboratory evidence of immunity, or</td>
<td></td>
<td></td>
<td>(3) Laboratory confirmation of disease, or</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td>(4) Born before 1957</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Postexposure Prophylaxis (PEP)
MMR Vaccine

- Administer within 72 hours of exposure
  - May return to normal activities (except health care settings)
  - Still monitor for symptoms
  - Can be given down to age 6 months
  - Be aware of possibility of vaccine rash
Postexposure Prophylaxis (PEP) Immune Globulin

- Administer within 6 days of exposure

- Recommended Dose
  - Intramuscular (IGIM): 0.5 mL/kg (max = 15 mL)
  - Intravenous (IGIV): 400 mg/kg

- Recommended for the following groups (risk of severe disease and complications)
  - Infants aged <12 months (IGIM)
  - Pregnant women without evidence of immunity (IGIV)
  - Severely immunocompromised patients (IGIV)
Does the Vaccine Really Work?

1,000 exposed
(90% vaccine coverage)

900 Vaccinated
(97% VE)

27 vaccinated cases

100 Unvaccinated
(90% attack rate)

90 unvaccinated cases

23% of cases vaccinated
Keys to Maintaining Elimination in the U.S.

- High 2-dose MMR vaccine coverage
- High quality surveillance
  - Rapid identification of and response to measles cases
  - Reportable within 24 hours per Council of State and Territorial Epidemiologists (CSTE) guidelines
- Aggressive outbreak control measures
- Information sharing tools (Epi-X, HAN)
Keeping Sight on the Successes

- Elimination Achieved & Maintained
- Vaccine Works, Disease Recognizable
  - Eradication Possible & Achievable
- Outbreaks are Limited (size & # of generations)
  - High Overall Vaccine Coverage
  - Rapid/Aggressive Public Health Response to (suspect) Cases
Measles Era Approaching Elimination

- Measles is due to Failure to Vaccinate
- Measles Elimination is a Global Problem
- Maintenance of Elimination is Resource Intensive
  - Maintaining vaccine coverage
  - Intensive case/contact investigations
  - Healthcare workers diagnostic skills
  - Advanced laboratory techniques
Summary of Measles Elimination in the U.S.

• Declared in the U.S. in 2000
  – Pan American Health Organization (PAHO) documenting for the Americas
• Huge Public Health Achievement
• Brings New Challenges
  – Case investigations very resource intensive
  – Continued global threat
  – Highly contagious
  – Clustering, accumulation, and aging of susceptibles