Population Movements and Infectious Disease: Measles as a Case Study

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Outline

- Measles background
- Measles dynamics in wealthy countries
  - Determinants of dynamics
- Measles dynamics in poor countries
- Case Study
  - Niamey, Niger (city-level)
  - Niger (country level)
- Conclusions
Measles Overview

- A leading cause of vaccine-preventable death among children

- ~410,000 children < 5 yrs die globally

- Primary reason for deaths is the failure to deliver at least one dose of measles vaccine

- Case Fatality Ratio (CFR)
  - Developing countries: 1-5%
  - Refugee/Displaced settings and among malnourished children: may reach 10-30%
Complications of Measles

- Corneal Scarring causing blindness
- Encephalitis
- Pneumonia & diarrhea
Epidemic Dynamics

- Seasonal disease
- Multi-year epidemic cycle
- Infectious period begins before rash
- Directly transmitted
- Herd immunity requires 90 - 95% population immunity
- Disease confers lifelong immunity
Characteristics of Measles Vaccine

- Attenuated, live, injectable vaccine
- Antibodies appear 12-15 days after vaccination
- Vaccine Efficacy (1 dose)
  - 85% 9 mo
  - 95% 12-15 mo
  - 98% with 2 doses
- Vaccination within 72 hours of exposure may decrease severity of disease and transmission potential
- <1$ per child (direct and indirect)
Recent Global Evolution of Measles Control

- **1990s**: Urban campaigns targeting 9m-5y in Africa

- **2000**: UNICEF/WHO Measles Mortality Reduction and Regional Elimination Strategic Plan 2001-2005 (WHO/V&B/01.13)
  - Strengthen routine immunization
  - Second opportunity for measles immunization
  - Enhanced surveillance
  - Improved case management

- **2000**: Measles Initiative
  - Reduce measles deaths by 90% worldwide by 2010 (compared to 2000).
Measles Mortality Reduction

47 UNICEF / WHO Priority Countries 1999

94% of all measles deaths

No second opportunity (47)
Pockets of highly endemic measles

- Precarious political situation
- Insufficient vaccination coverage
- Limited access to care
- High birth-rates
- High population density
- Health Inequalities
Epidemic Dynamics

WHO guidelines (1999)

- Spread so fast it’s always too late to intervene
- Scarce resources best invested elsewhere
- Based on literature review and mathematical models of epidemics in non-African settings (mainly England and Wales)
Measles in England and Wales

- Strong epidemic oscillations
- Well described by SIR models
Determinants of measles dynamics in wealthy countries

- Seasonality
  - School terms
  - Christmas holidays

- Spatial spread of epidemics
  - Transportation within cities
  - Transportation between cities
# Measles dynamics in high burden countries

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<th>Place</th>
<th>Year</th>
<th>Length (months)</th>
<th>Cases</th>
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</table>
Economic Context

- Economy centers on:
  - subsistence crops
  - livestock
  - uranium deposits

- 2000: qualified for enhanced debt relief IMF-Highly Indebted Poor Countries (HIPC)

- 2005: 100% multilateral debt relief (IMF)

- Nearly 50% of the government's budget is derived from foreign donor resources
Health Context

- Health System (access to care)
  - 377 physicians
  - 21 midwives
  - 15 dentists
- Out of pocket expenditure: 89%
- Children with fever receiving antimalarials: 48%
- Vaccination coverage for 1 year olds (administrative estimates)
  - Measles 74%
  - DTP3 62%

WHO Country Health System Fact Sheet, 2006
Health Context, continued

- Life expectancy at birth (2005): 45 yrs
- Fertility rate (children per woman): 7
- U5 mortality 259/1000 live births
  - Neonatal causes 17%
  - HIV/AIDS 1%
  - Diarrheal diseases 20%
  - Measles 7%
  - Malaria 14%
  - Pneumonia 25%

WHO Country Health System Fact Sheet, 2006
Overview of methodology

- Epidemic dynamics at annual level
  - Grais RF et al. J R Soc. 2008 Jan 6;5(18)

- Epidemic dynamics at multi-annual level
  - Ferrari et al. Nature. 2008 Feb 7;451(7179)

- Epidemic dynamics at regional level
Reported Measles Cases, Niamey, Niger 1985-2003

Source: Ministry of Health, Niger
Reported measles cases in Niamey, Niger (2003-2004) (10880 cases)
Effective Reproductive Ratio, 2003-2004 measles epidemic, Niamey, Niger

Source: Grais et al, TRSTMH, 2007
Critical Community Size

- Population size necessary for persistence
- Strong seasonality in Niamey results in higher CCS

Seasonal Dynamics

Regional dynamics: rainfall

Epidemic dynamic drivers in High Burden Settings

- **Seasonality**
  - Rainfall
    - Contact patterns
    - Virus viability
  - Population Migration
    - Harvest related seasonality
  - Birth rate
  - Access
Public Health Implications

- Strong seasonality of transmission in Niamey leads to different dynamics than predictions based on industrialized countries in the northern hemisphere.
- Dangers of extrapolating dynamics for these without a detailed understanding of local situations.
- Understanding of population dynamics (seasonal migration, climate) essential for control.
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