1997 Measles Outbreak in São Paulo, Brazil: Evaluation of Vaccination Strategies via Mathematical Modeling

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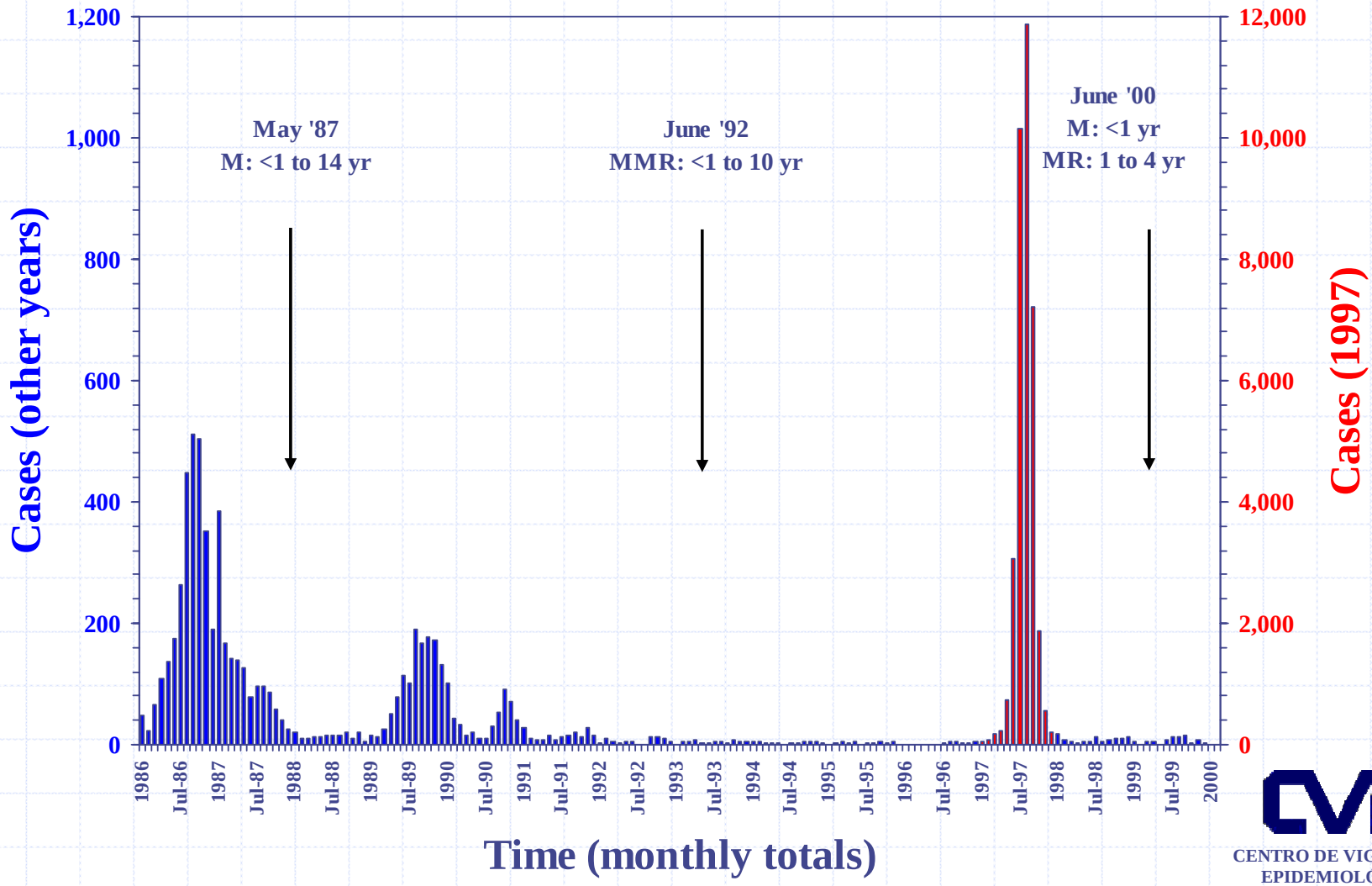
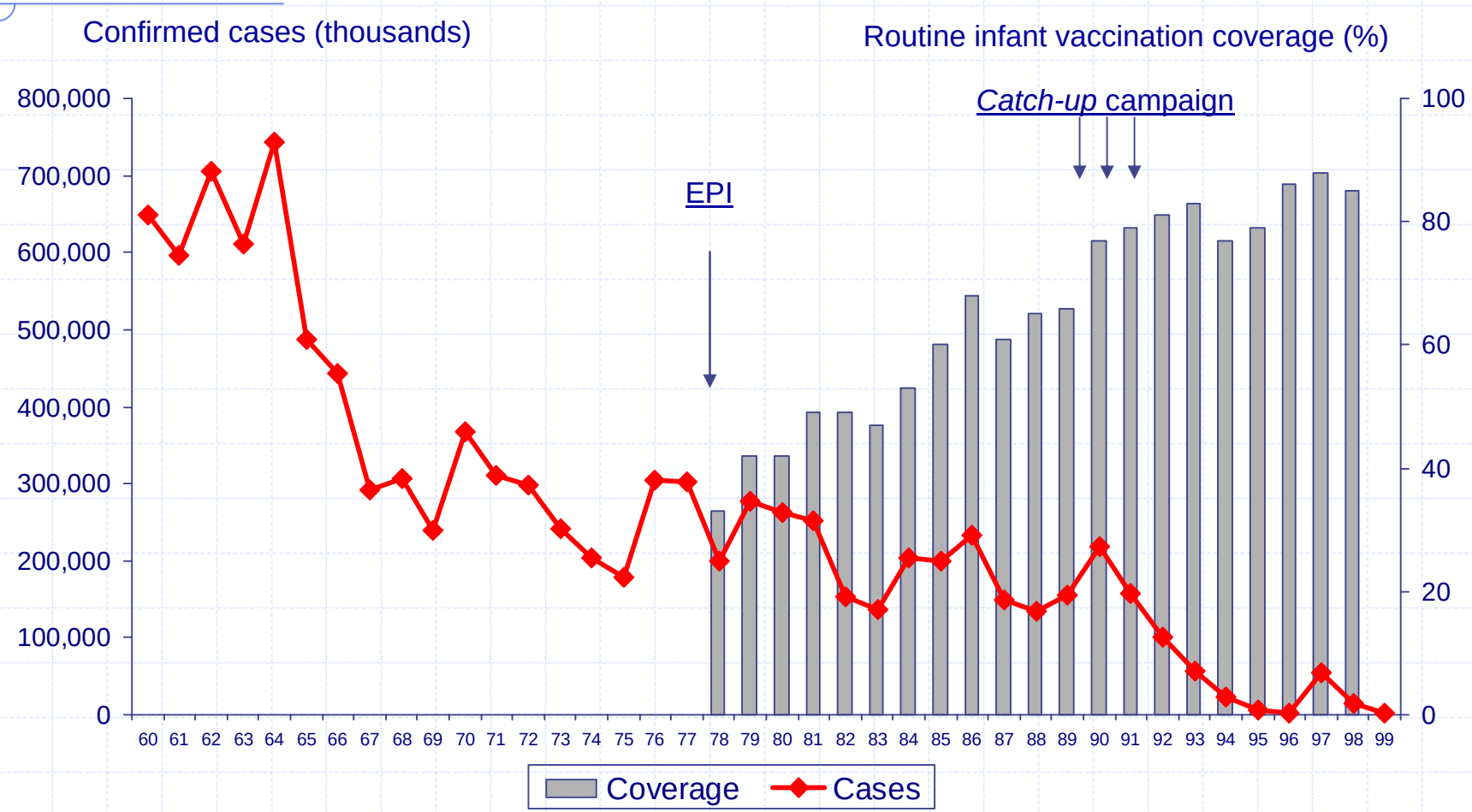
Measles in Metropolitan São Paulo, 1986-'99



CENTRO DE VIGILÂNCIA EPIDEMIOLÓGICA

"Prof. Alexandre Vranjac"

Vaccination Coverage and Reported Cases of Measles, Region of the Americas, 1960-1999*#



Source: PAHO/WHO

* Data as of 16 October 1999 -2,372 confirmed cases

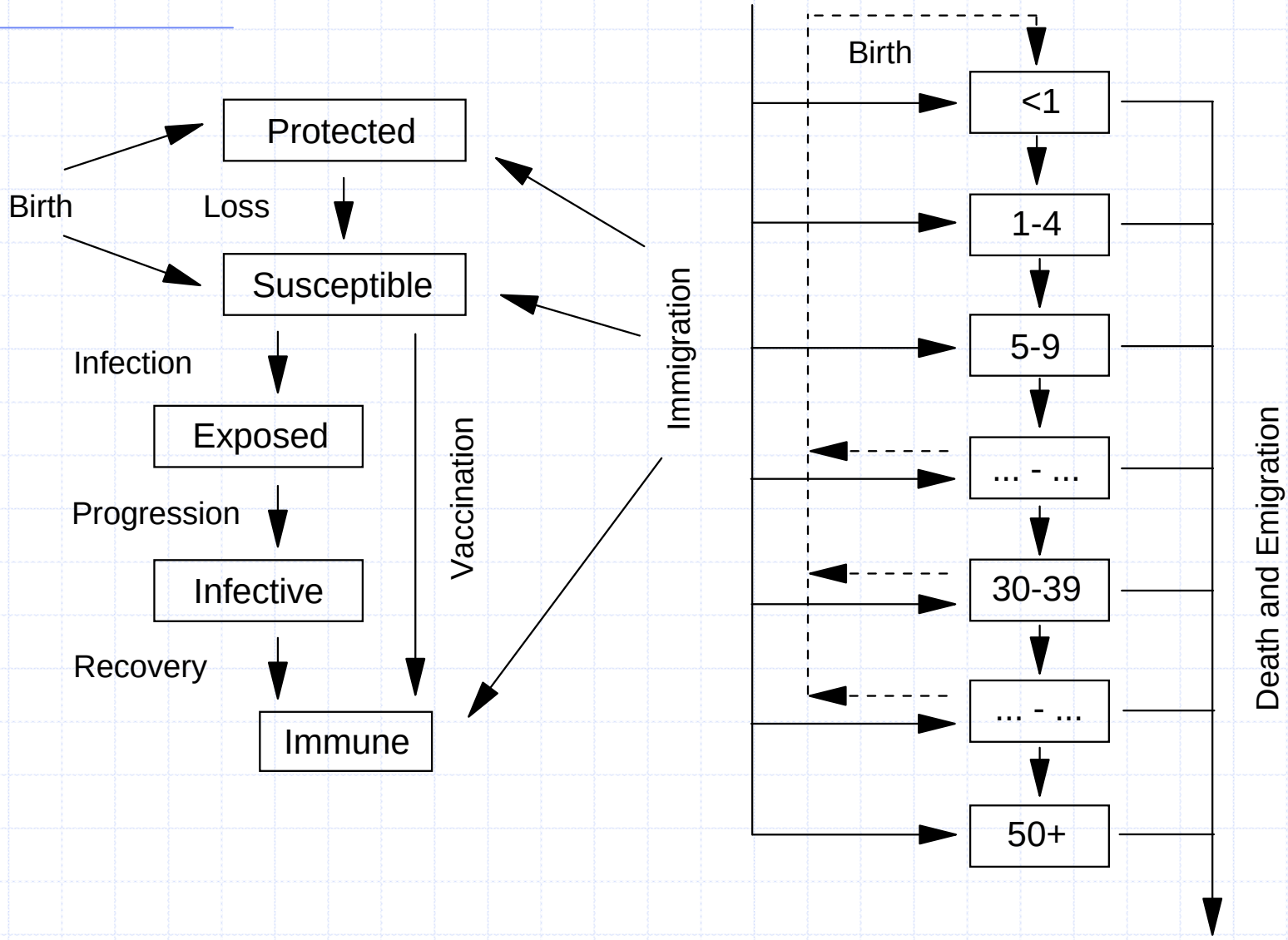
[#] Coverage data for children <1 year of age
1999 coverage not yet available

PAHO

Questions

- Would a follow-up campaign during June-August of 1996 have prevented or ameliorated the ‘97 outbreak?
- What impact did efforts to control this outbreak have?
- Would vaccination of immigrants, particularly from northeastern states, reduce the risk of future urban outbreaks?

Conceptual Model I



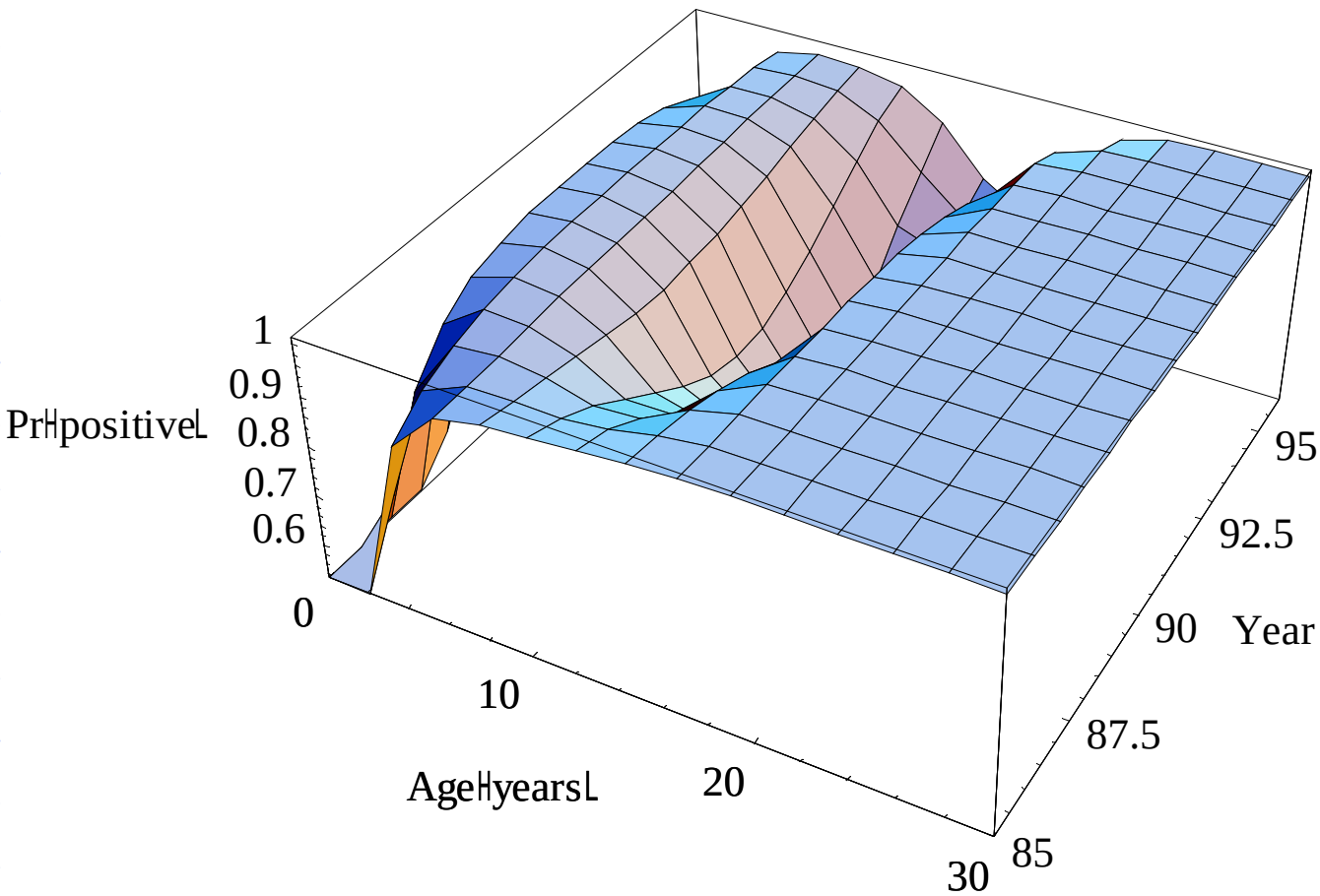
Parameters

- Demographic: Vital statistics, including not only resident population and births and deaths, but immigration and emigration rates
- Programmatic: Age-specific vaccine efficacy, age distributions of routine doses, timing and target ages of campaigns, coverage
- Epidemiologic: Proportions of each resident age class susceptible/immune, characteristics of immigrants, natural history of disease

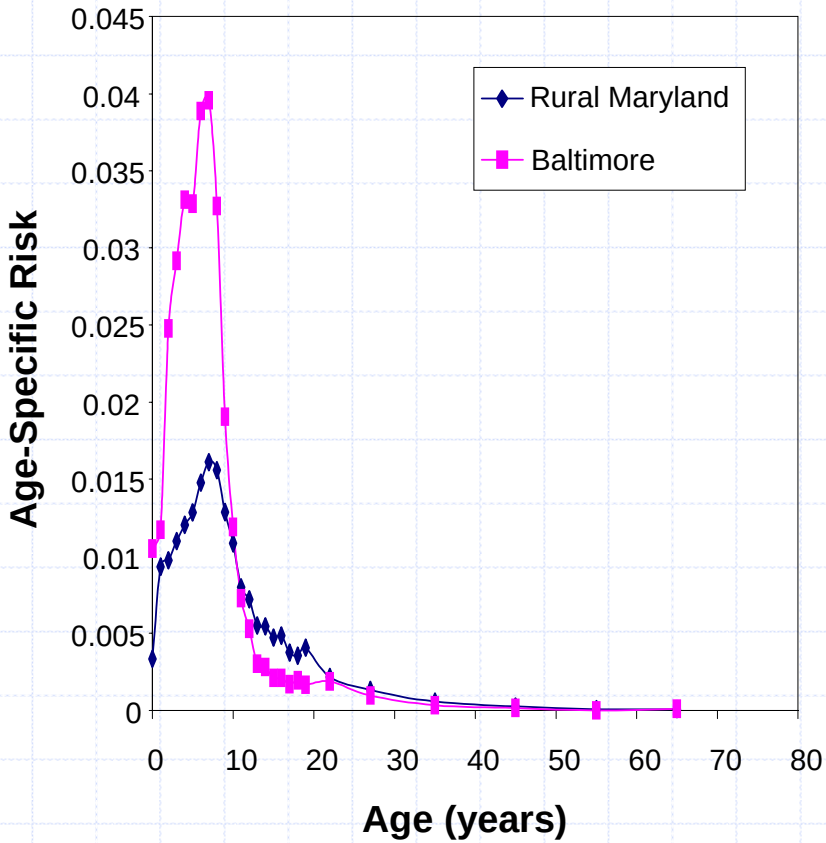
Approach

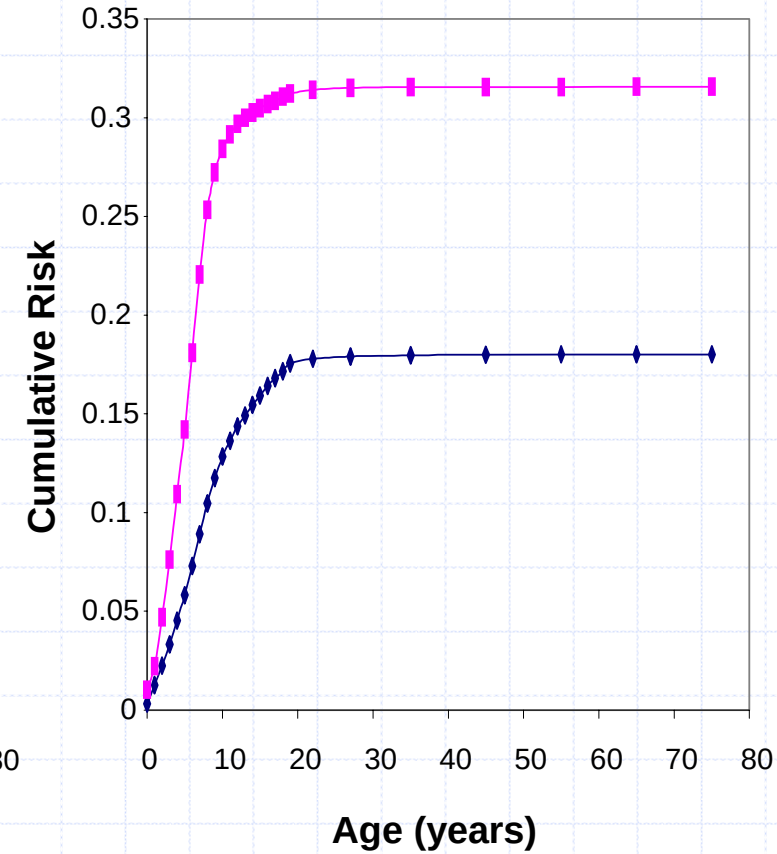
- Setting-specific information supplemented from elsewhere, informed opinions
- Several parameters adjusted to increase concordance between simulated and reported cases via direct-search algorithms
- Deduced impact of actual and hypothetical interventions, conditional on routine childhood vaccination, experimentally
- Model of loosely-coupled rural, urban and recent immigrant sub-populations planned

Measles Immunity in São Paulo

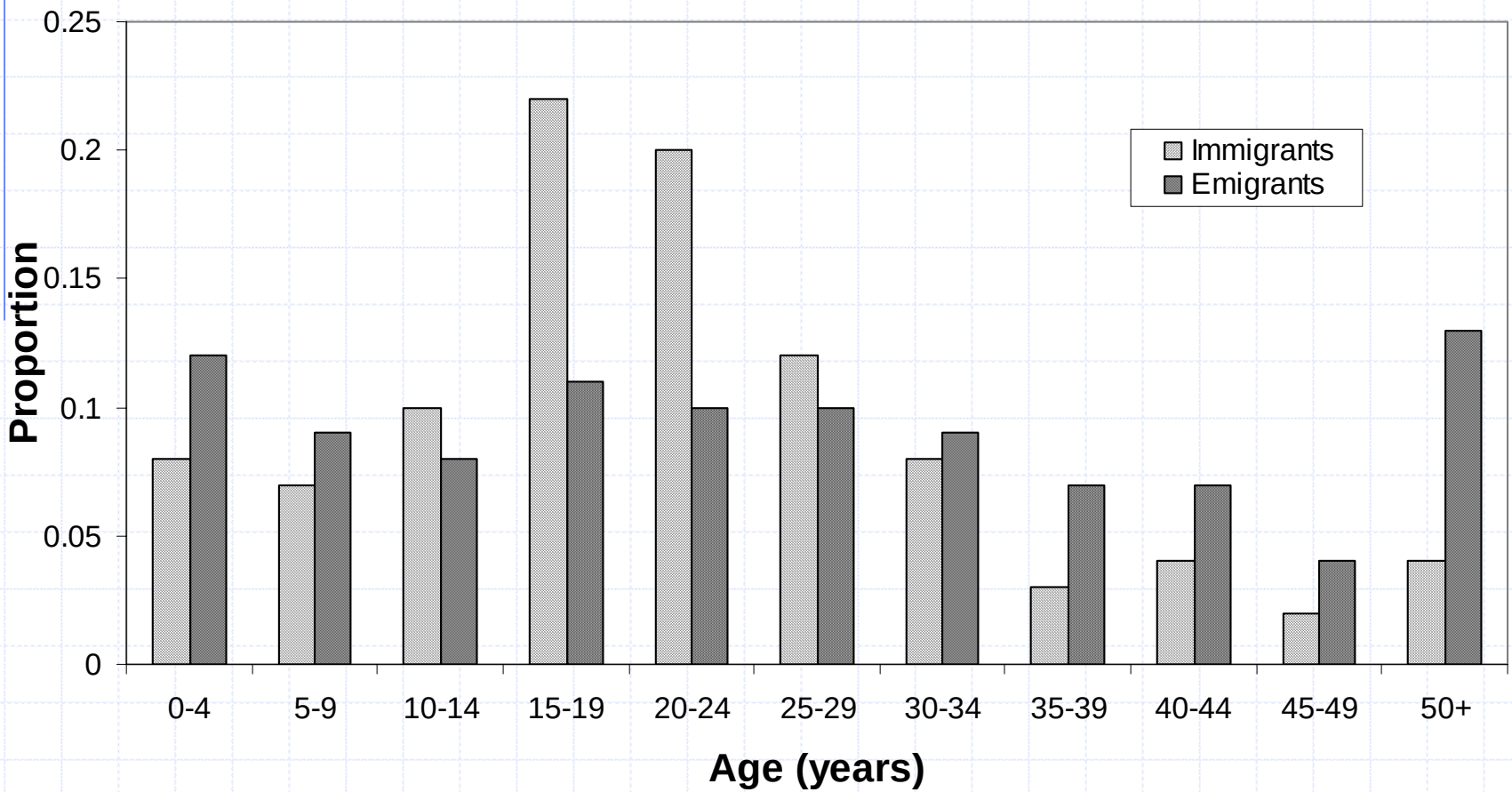


Forces of Infection from Measles Histories in Maryland, 1908-’17

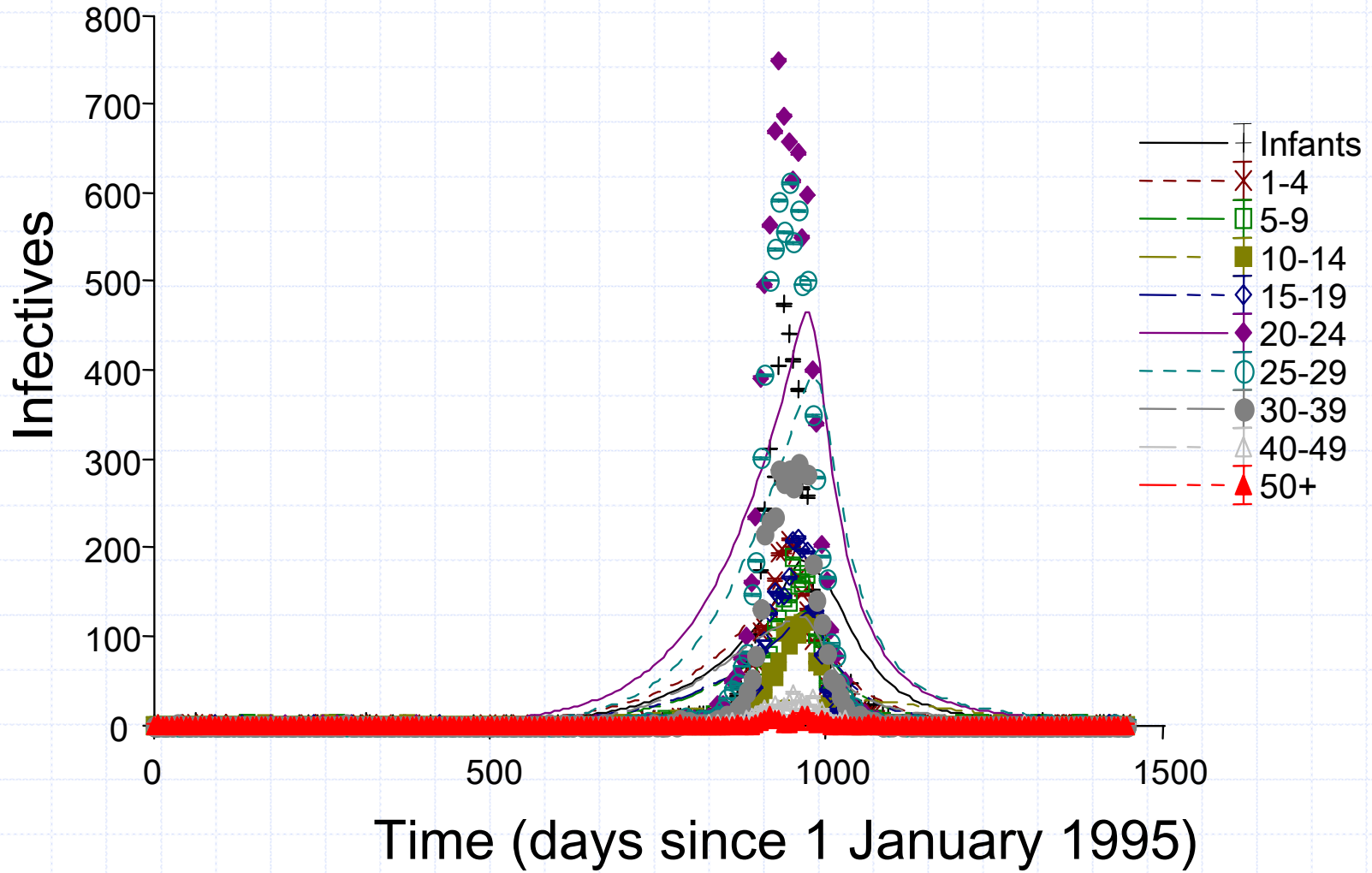




Migration among Residents of São Paulo for <4 Years, 1994



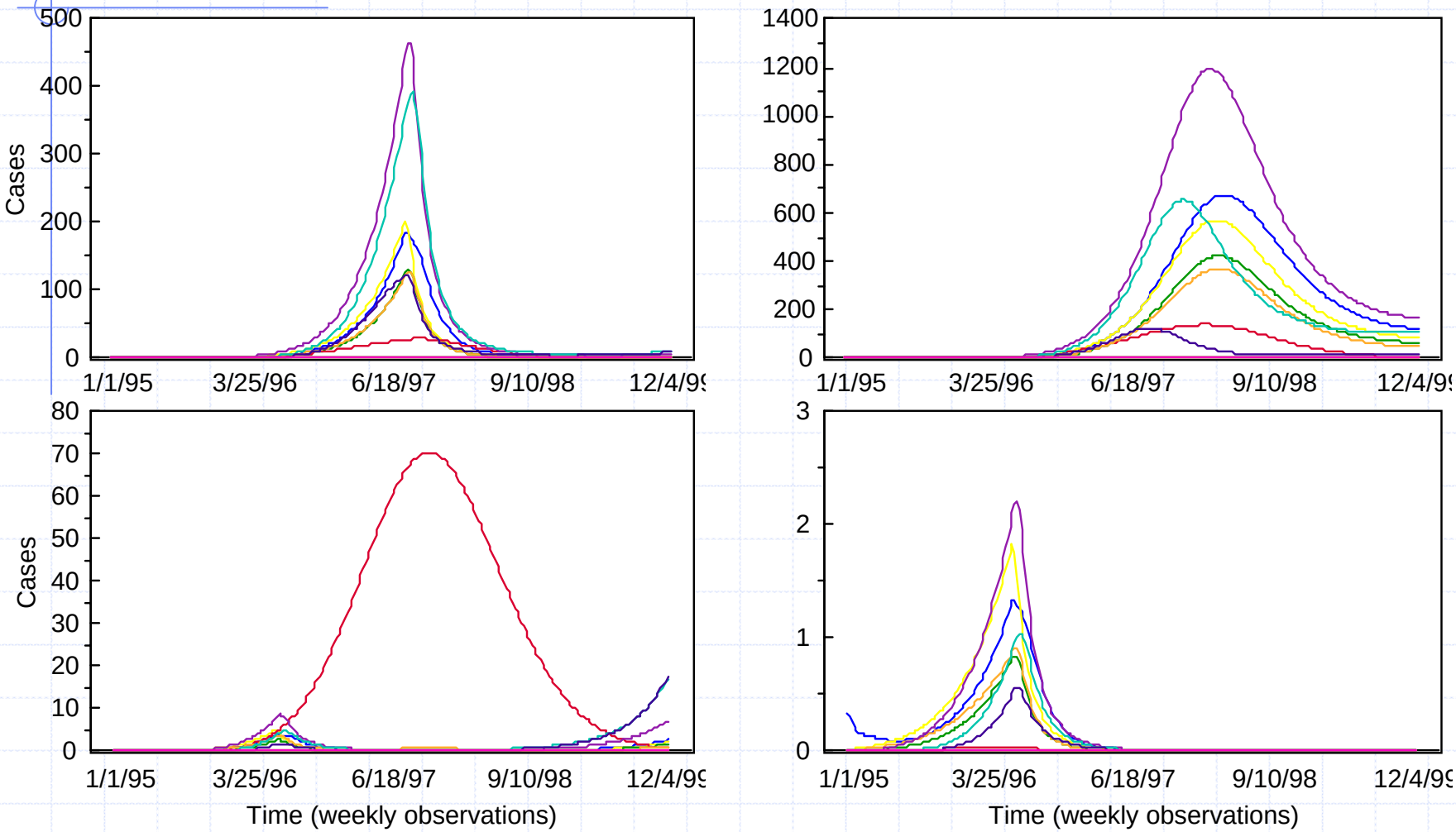
São Paulo, Brazil



Three Experiments: Compare Successive Pairs of Four Scenarios

- With routine two-dose childhood program and outbreak-control efforts
- Without outbreak-control efforts
- With a follow-up campaign during the week of 15 June 1996
- With supplementary adult vaccination having the age distribution of immigrants

Simulated Actual and Three Hypothetical Scenarios



Qualitative Results

- Control efforts directed solely at children were surprisingly effective, given that most cases were over 20 years of age
- Follow-up campaign would have been even more effective, but missed susceptible adolescents, permitting future outbreaks
- Vaccination of young adults, possibly via workplaces of unskilled recent immigrants, would prevent outbreaks

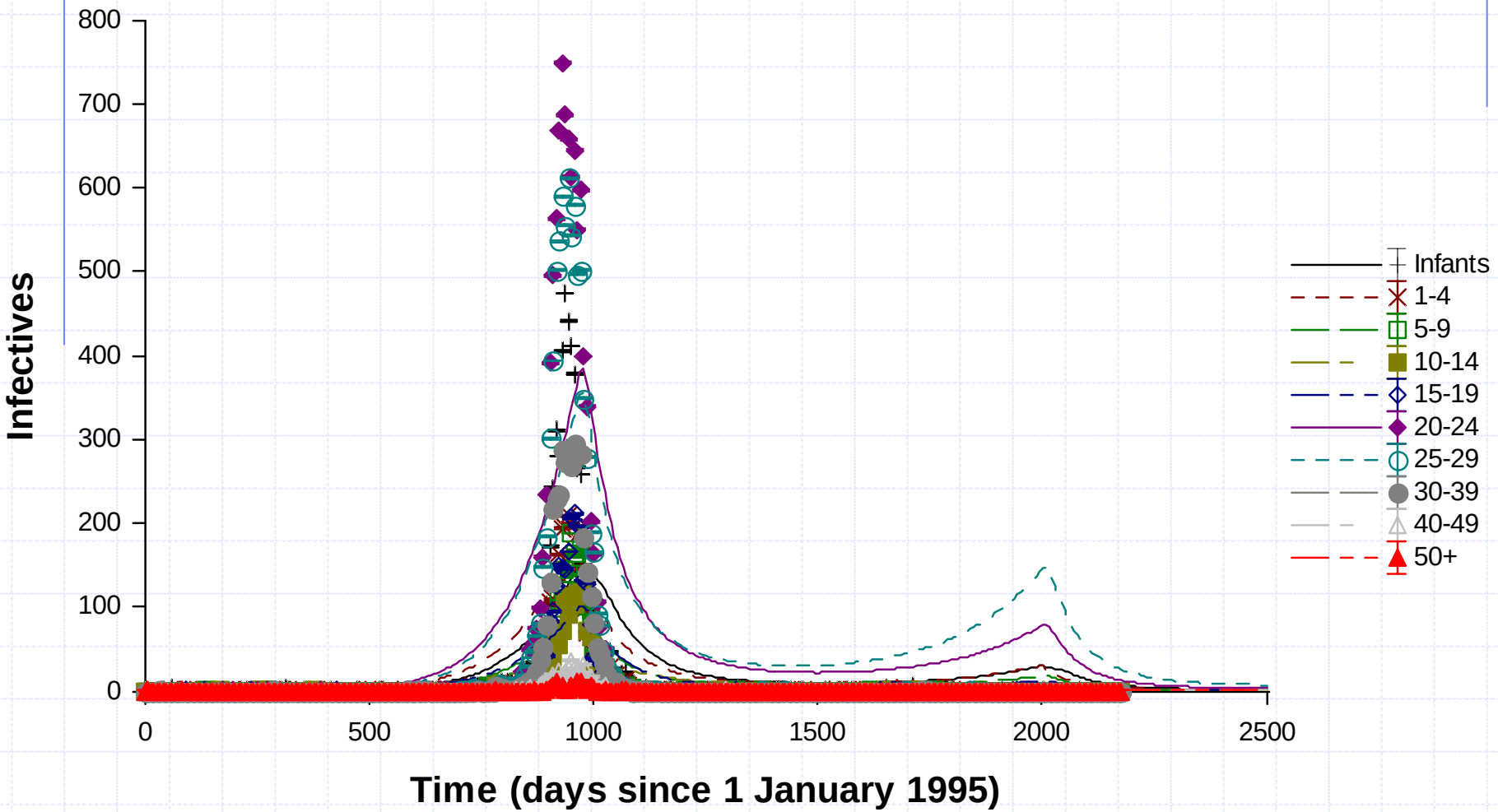
Limitations and Refinements

- More reliable current and historical coverage estimates
- Representative historical or immediately *pre-outbreak* serological surveys
- Historical and projected age-specific rates of immigration and emigration
- Serosurveys where immigrants originate to determine age-specific immunity

Implications of Conclusions

- Some susceptible young adults were long-time urban residents, neither vaccinated as children nor infected subsequently
- But most recently immigrated, by virtue of disparate economic opportunities, from areas whose population immunity is less
- Insofar as neither phenomenon is unique to São Paulo, policymakers must consider heterogeneity within and among populations

São Paulo, Brazil



Postscript

- Adolescent/young adult immigrants not targeted as recommended, but …
- A mass campaign was conducted June 2000 to avert predicted measles outbreak
- An outbreak of rubella with similar age distribution occurred soon afterwards in São Paulo, …
- With, consequently, many cases of congenital rubella syndrome†, …
- That, in turn, were followed by a rubella catch-up campaign among women 20-29 years of age

†Lanziere et al. 2003. Pediatr Infect Dis J 22:323-29;
2004. Pediatr Infect Dis J 23:1116-22