Investigation of childhood immunization coverage in Michigan using survival analysis methods

Kyle S. Enger, Division of Immunization, Michigan Department of Community Health (MDCH); engerk@michigan.gov (abstract 2064)

Introduction

Background:

- Various coverage measures for children of particular ages are popular (notably 431331 for 19-35 month olds)
  - Very familiar, easy to calculate, easy to compare
- However, they do not describe time-at-risk very well
  - A child immunized at age 19 mos. risks disease 6 mos. to 1 y. longer than a child immunized on time, but this difference is ignored
  - Survival analysis can address this

Data source: Michigan Care Improvement Registry (MCIR)

- Immunization information system (IIS); operational since 1998
  - More information: http://mcir.org
- Covers people of all ages: < 20 y age restriction removed in June 2006
- ~95% of Michigan immunization providers participate
- Part of CDC's IIS sentinel site project
  - www.cdc.gov/nip/registry/st_terr/activities/sentinel-faqs.htm
- Michigan's population is large: 10 million people, 130,000 births/year

Methods

Survival analysis:

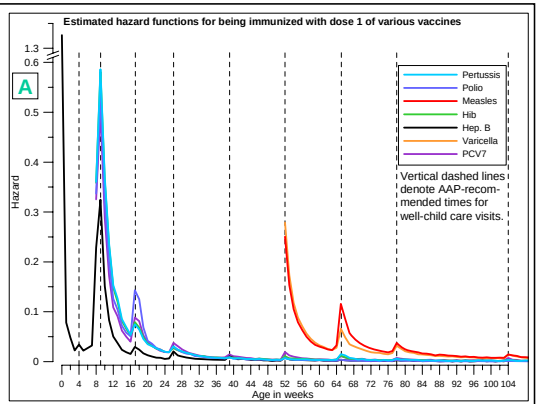
- Survival analysis concerns elapsed time before an event.
- The event must be unique (e.g., death, cure, 1st immunization).
- Key tools: survival & hazard functions (counterintuitive):
  - High 'hazard' → children immunized sooner → **GOOD!**
  - High 'survival' → Fewer children immunized → **BAD!**
- 'Survival' function (NOT chance of actually surviving):
  - Probability that the 1st immunization occurs after a given time
  - Starts at 1 and declines toward 0 as time increases
  - Can be viewed as the % reaching any given time without immunization
- 'Hazard' function (Does NOT describe risk of adverse events):
  - Describes # of expected 1st immunizations per person per week
  - Can be >= 0 and may rise & fall as time increases
  - Measures how likely 1st immunization is at any time for people who haven't been immunized yet

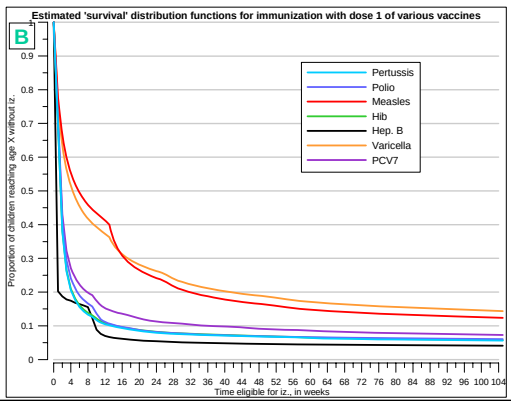
Analysis methods:

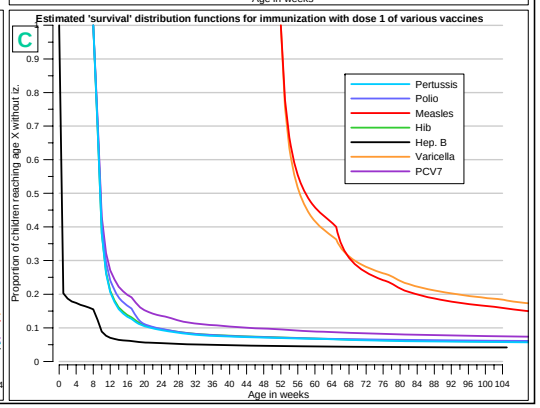
- For all childhood immunizations (1st dose only):
  - Estimated survival & hazard functions by week using SAS 9
- Study population
  - Children born in MI with 1-3y of followup on 1 May 2007
  - 2y birth cohort; ~ 240,000 children
- Stratified by region, race, Pb risk, Pb testing, WIC, Medicaid
  - Used multivariate Cox regression in SAS 9 (models are preliminary only)

Results: Hazard & survival estimates

- Hazards peak at well-child visit times (chart A)
  - Peaks indicate likely times for immunization
  - Very high for birth dose of hep. B (note break in Y axis)
- Survival functions (charts B & C) drop quickest when child first becomes eligible
  - Charts B & C are identical, except for the X axis
    - B: time eligible for immunization, C: age of child
  - Chart B shows that 1st immunization for measles & varicella occurs slower than for other childhood iz.
    - Probably because younger babies have more checkups
- To better understand survival & hazard functions, compare charts A & C (identical X axes)

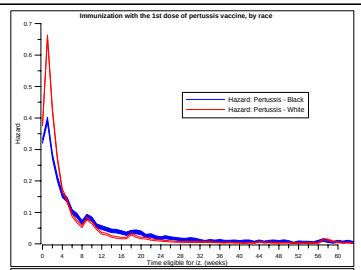


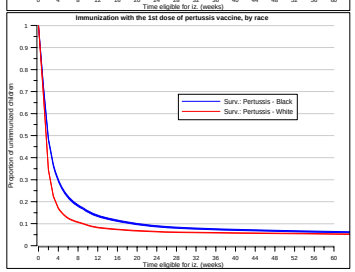




Results: Black/White

- 1st dose of pertussis charted
- 18% black, 82% white
- Line thickness is 95% confidence
- White kids have a higher hazard initially, but the hazard for black kids later surpasses it
- Hazard ratio: 0.84 (black/white)
  - 0.60 at 1 wk., but 1.13 at 7 wks.
- Black kids lag white kids initially, but catch up over time. The white area between the survival curves indicates the disparity.
- Early disparities that resolve over time, like this one, are hard to detect using standard coverage estimates.





Preliminary results: Multivariate Cox regression

Hazard ratios have P < 0.001 unless otherwise noted.

Hazard ratio (1st pertussis dose)	Risk factor	Hazard ratio (1st measles dose)
0.98 (P = 0.002)	Region 1a (ref.=region 3)*	0.96
0.94	Region 1b (ref.=region 3)*	0.78
1.04	Region 2 (ref.=region 3)*	1.04
Not significant (P >> 0.05)	Region 4 (ref.=region 3)*	Not significant (P >> 0.05)
0.95	Region 5 (ref.=region 3)*	1.04
Not significant (P >> 0.05)	Region 6 (ref.=region 3)*	0.97 (P = 0.07)
0.86	Medicaid-enrolled †	1.05
1.15	WIC-enrolled †	1.06
0.87	Black (ref.=white)	0.84
Not significant (P >> 0.05)	American Indian (ref.=white)	0.93 (P = 0.02)
1.03 (P = 0.02)	Asian/Pacific Islander (ref.=white)	0.98 (P = 0.07)
Not significant (P >> 0.05)	Hispanic (ref.=no ethnicity)	Not significant (P >> 0.05)
Not significant (P >> 0.05)	Arab (ref.=no ethnicity)	1.06
0.94	Lives in high-risk Pb area	0.92
1.19	Tested for Pb	1.40

* Region 1a: SE MI (Livingston, Macomb, Monroe, St. Clair, & Washtenaw counties; Region 1b, Oakland & Wayne (incl. Detroit); Region 2: SW Lower Peninsula; Region 3: central Lower Peninsula; Region 4: Thumb & Saginaw Bay area; region 5: northern Lower Peninsula; Region 6: Upper Peninsula.

† When first eligible for vaccination, i.e., at age 2 months for pertussis or age 1 year for measles.

Discussion

- Fine detail can be seen due to large sample size.
- Disparities may be small, but they are statistically significant.
- The Detroit area (region 1b) was included despite lower (but increasing) MCIR participation; if excluded, the black/white disparity is smaller.
- Local application of this analysis could guide public health programs.
- Multivariate analysis will continue. Other possible risk factors:
  - Census data by tract: income, education, family size, etc.
  - Program data: local health department staffing/funding
  - Interaction terms, time-dependent variables (e.g., Medicaid, WIC)

Acknowledgements

Thanks to B. Swanson, P. Vranesich, T. Hoyle, R. Potter, & the CDC IIS sentinel site program for their support.