Pediatric Pedestrian Injuries and Safe Routes to School

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Funding

- New York City Department of Transportation
- Centers for Disease Control and Prevention 1 R21 CE001816 and 1 R49 CE002096
- National Institute for Child Health and Development 1R01HD087460-01

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Some Conclusions

- Traffic Calming Works
- Evaluation Necessary
- Kids can still be kids and be safe

Overview

- Pediatric Pedestrian Injury in NYC, 1990-2000
- Safe Routes to School Program in NYC
- Texas and National SRTS
- Spatial Analysis and Large Data

Pediatric Pedestrian Injury in the US

- 25% of pediatric mvc deaths are pedestrian (vs. 5-10% adults)
- leading cause of TBI in kids
- about half all injury-related pediatric hospital admissions each year
- 579,621 ED visits 1- 19 y/o 2001-2010
  - 8,651 deaths
  - 23% psych sequellae
- Decreased activity, obesity

Pedestrian Injury in NYC

- 1572 total fatalities 2004-2008 (~300 per year)*
  - 35% decrease since 2001
  - 3.5 fatalities per 10,000 population (lower than Copenhagen)

- 168,000 total injuries over recent 10 years, or ~ 16,800 per year

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* New York City Pedestrian Safety Study and Action Plan, 2010

Pediatric Pedestrian Injury Study 2000

- NYC DOT Compiled NYPD Police Crash Reports
  - MV104AN
  - 700,000 MVCs NYC 1991-1997; 1.5 million vehicles; 900,000 injured; 100,000 pedestrians
  - 27,377 crashes involving ages 5-19
  - 149 Fatalities (54 per 10,000)
  - 18,117 (66%) vehicle information (VIN)

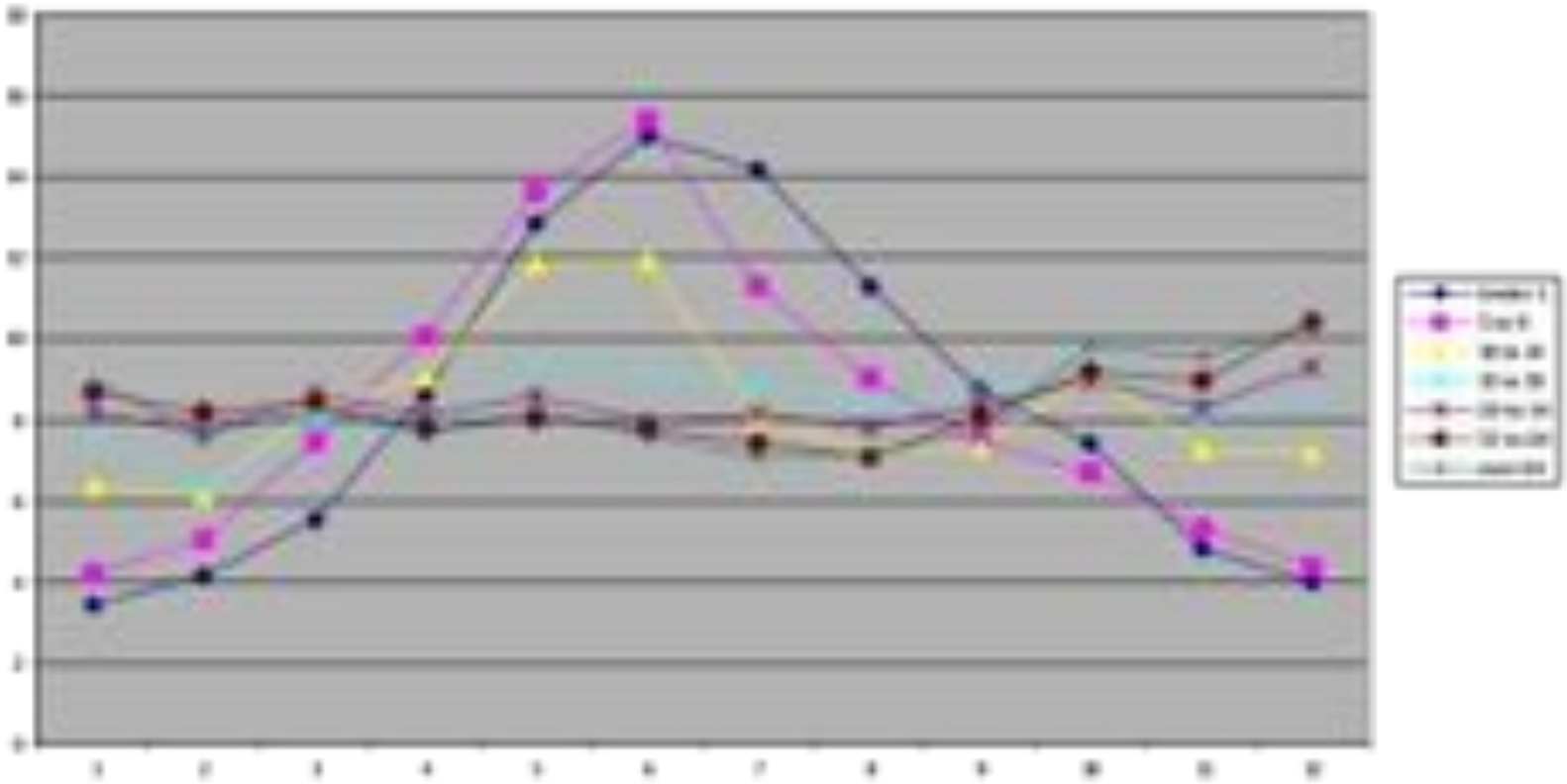
- Analysis
  - 5-9, 10-14, 15-19
  - Frequencies, Odds Ratios Association Fatality
  - Logistic regression LTV (exposure) fatality (outcome)
    - Covariates: driver age, driver gender, vehicle weight

Pediatric Pedestrian Risk in the 1990s

- Yearly Injury Rate 1991-1997, 5-19 y/o's: 246/100,000
- Males, 9 y/o, weekdays, summer
- Younger than 10 years:
  - 22.6% increase population
  - 41.5% decrease injury rate
  - Stable CFR (<1%)

Academic Emergency Medicine
January 2002
Vol. 9, No. 1
aemj.org
Official Journal of the SOCIETY FOR ACADEMIC EMERGENCY MEDICINE

Summer Injuries Younger Children



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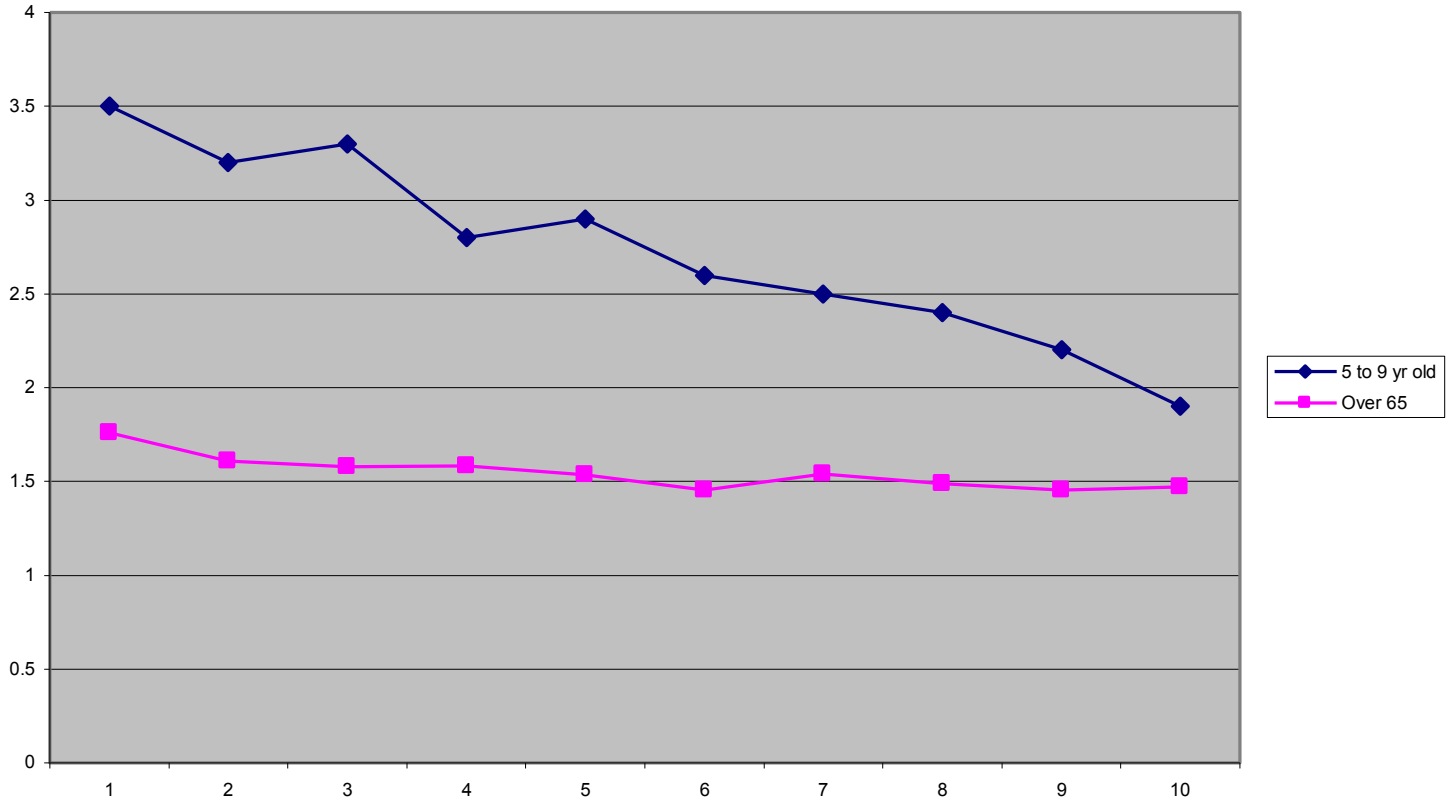
Pediatric vs. Geriatric Trends

Comparison Injury Rates per 1000 5 to 9 Years Old vs. 65 and Over, NYC, 1991-2000.



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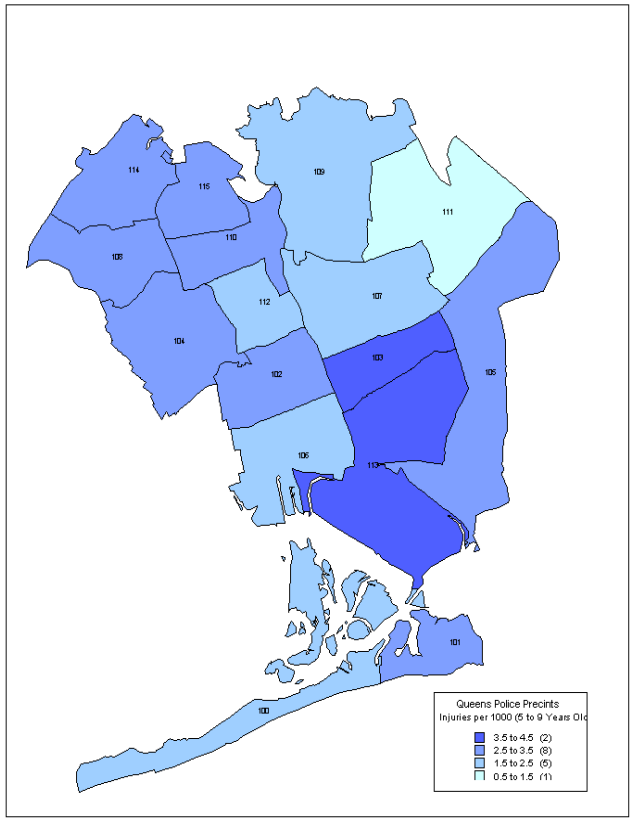
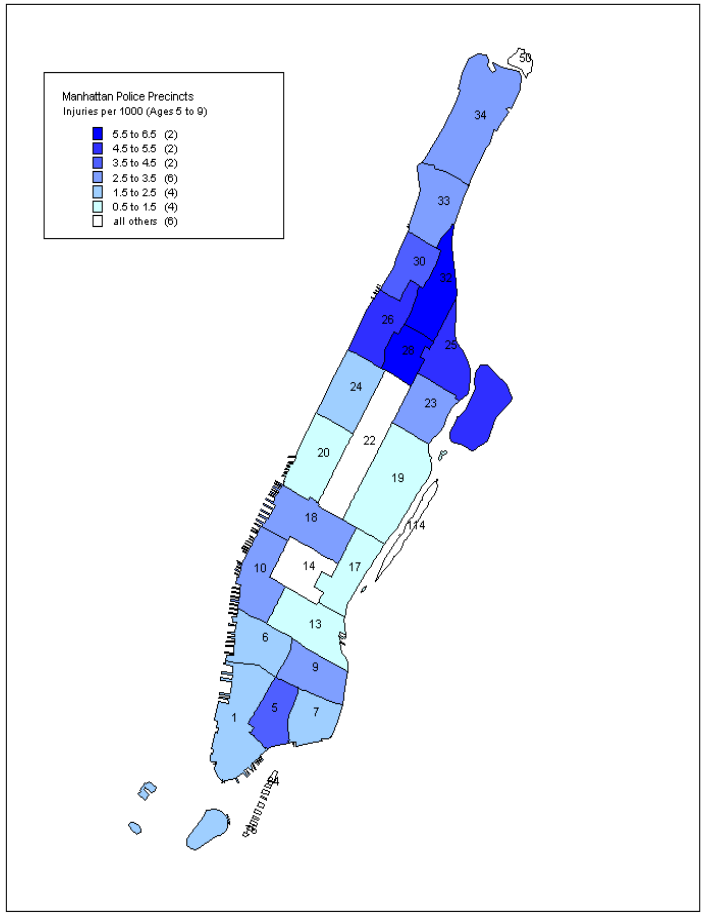
NYPD Precinct-Based Rates





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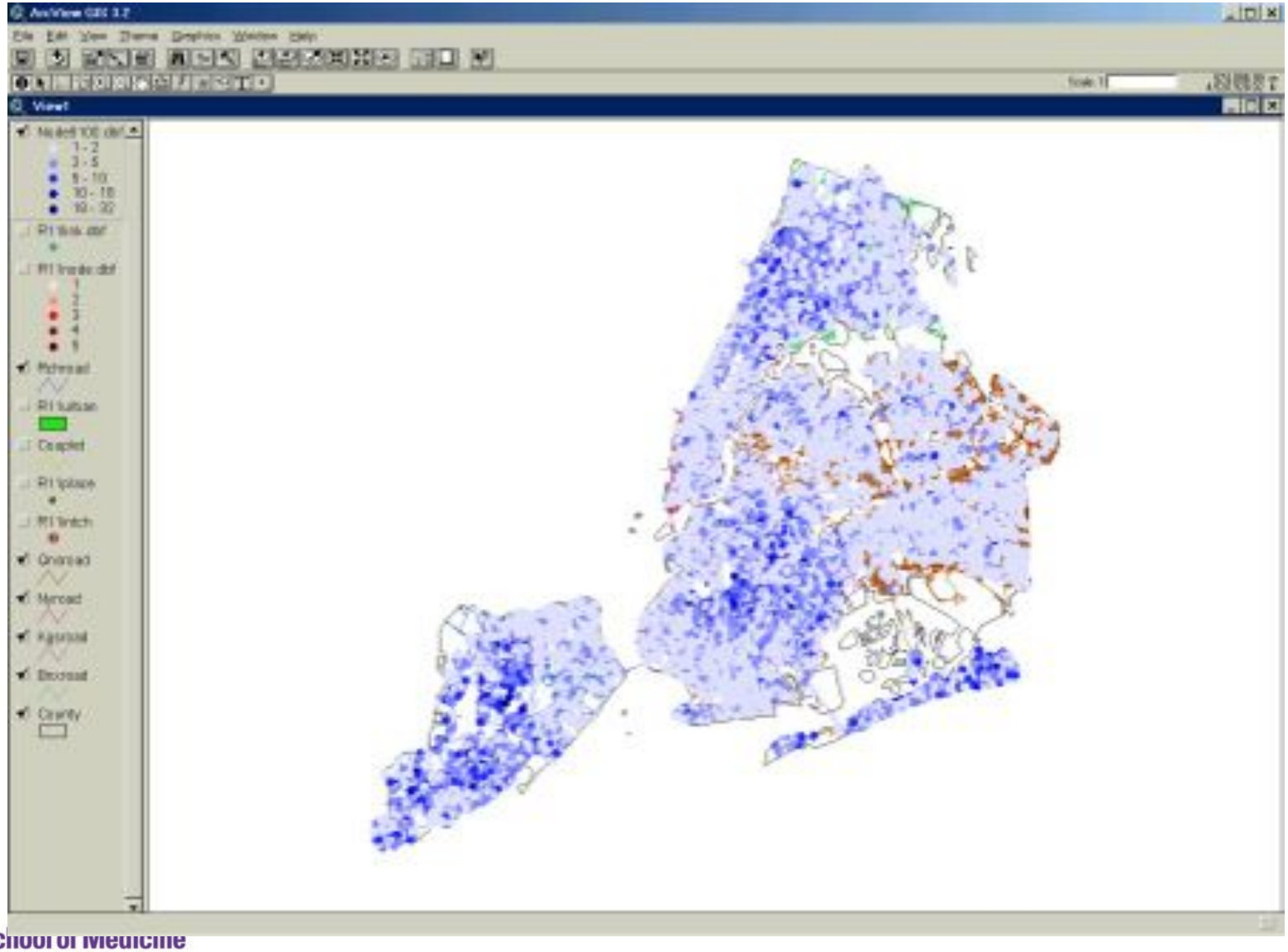
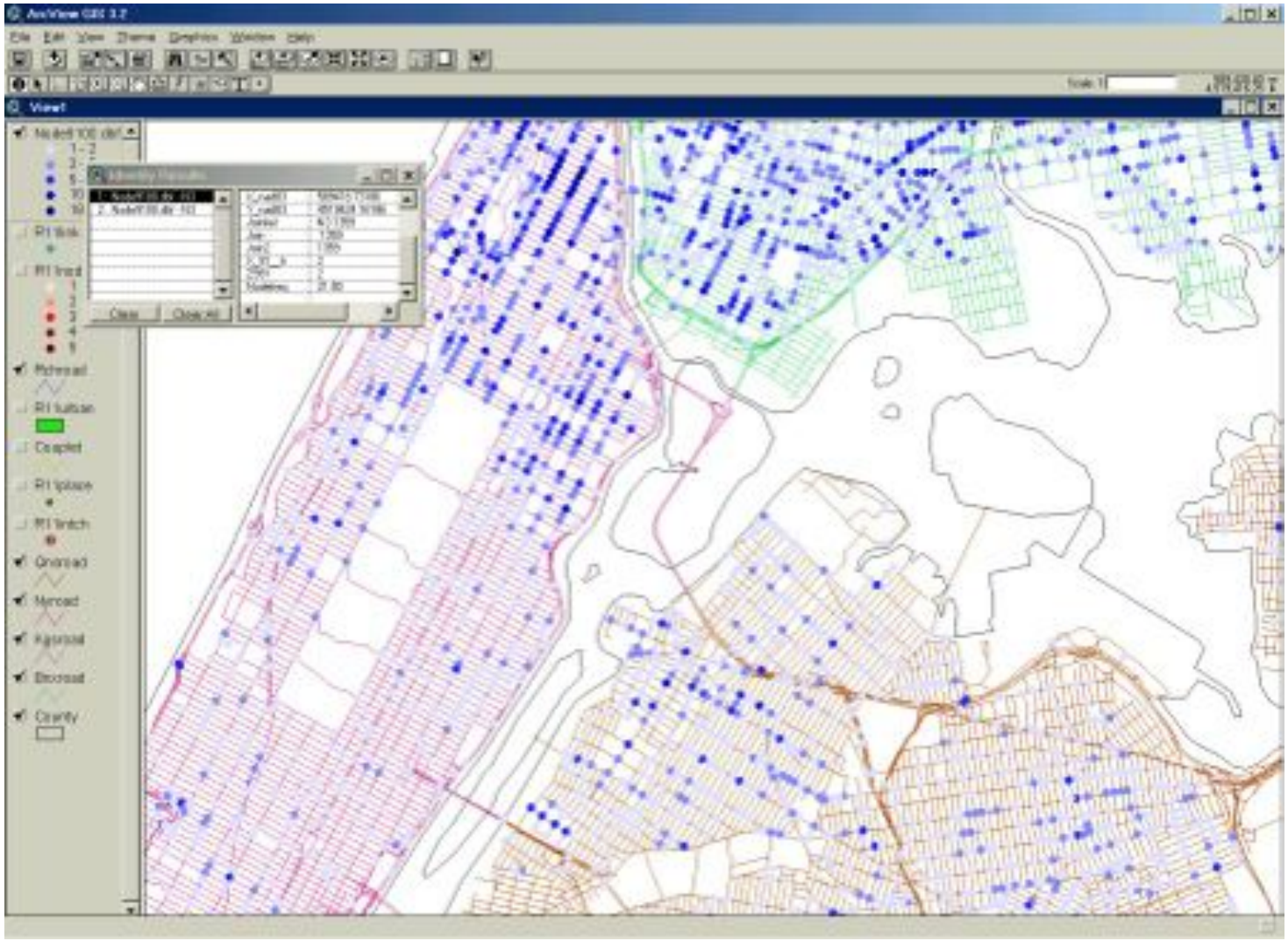
Point Process Data (Link/Node System)



GIS



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Analyses

- Association with Fatality (Univariate)
  - Driver age < 25: OR = 2.0 (95% CI 1.2, 3.1)
  - Male driver : OR = 2.2 (95% CI 1.1, 4.3)
  - Head Injury: OR = 2.5 (95% CI 1.6, 3.7)

- Light Trucks and Vans*
  - 5-19 y/o OR - 2.5 (95% CI 1.6, 3.8)
    - *5-9 y/o OR - 4.2 (95% CI 1.9, 9.5)*
    - 10-14 y/o - 1.0 (0.3, 2.9)
    - 15-19 y/o - 2.5 (1.0, 6.5)

* Logistic Regression Controlling for Driver Age and Gender, Vehicle Weight

International Journal of Injury Control and Safety Promotion, Vol. 13, No. 2, June 2006, 95–99

Taylor & Francis

The association of light trucks and vans with paediatric pedestrian deaths

CHARLES DIMAGGIO*†, MAUREEN DURKIN‡ and LYNNE D. RICHARDSON§

Interaction TBI with LTV?

- Younger kids had more head injuries
  - OR for 5-9 y/o = 1.6 (95% CI 1.5, 1.7)
- But association did not differ by body type
  - LTV OR =1.7 (1.4,2.0) Car OR=1.6 (1.5,1.7)

- Head injuries associated with fatality for all kids: OR 5-19 y/o=2.5 (95% CI 1.6,3.7)
  - But as likely to result in fatality in subgroup
    - 5-9 y/o OR = 2.5 (1.3, 4.9), 10-19 y/o OR=2.3 (1.4, 3.7)
  - As likely to result in fatality in both body types:
    - LTV OR=2.5 (1.2,4.9) Cars OR=2.4 (1.4,3.9)

LTVs more likely to *strike* younger children?

- Theoretically Plausible
  - carriage height + pedestrian height = visual obstruction
- Physics (?)
  - Speed
    - $F=mv^2/2$
  - child hit by vehicle at 30 mph 50% survival
  - 18 mph, 90% survival
- Not Supported by Data
  - Association LTV + Age: 5-9 y/o OR=1.2 (1.1, 1.4), 10-19 y/o OR=1.1 (1.0, 1.3)
    - Measurement error – head injury

Some Conclusions

- Declines in pediatric pedestrian injury in NYC
  - Activity …
    - Ian Roberts "Why have child pedestrian injury rates fallen?", BMJ, 1993
- LTVs are associated with fatal pediatric pedestrian injuries in youngest pedestrians
  - Engineering…
    - Mostly kids, TBI, measurement

What next?

- Large routinely collected administrative databases are useful epidemiologic tools
  - advances in computing
  - advances in analysis

- Possible Interventions: ”New York Model” (Susan Standfast, MD)
  - *engineering*, enforcement, education
    - evaluation, *environment*, EMS…

Safe Routes to School

- 2005 US DOT legislation $612 million
  - by 2012, total about $1.12 billion
  - 10,000 of nation's 100,000 schools
  - get kids walking / biking (safely) to school

- 130 of 2,000 NYC schools
  - Traffic and pedestrian signals, exclusive pedestrian crossing times, speed bumps, speed boards, sidewalk extensions; ~ 700 ft. buffer

Traffic Calming

- reduce pedestrian injuries by slowing traffic, ceding (some) rights to pedestrians, disincentives for driving
  - road narrowings,
  - new traffic and pedestrian signals,
  - timed crossings that allow pedestrians to cross before cars,
  - speed bumps,
  - speed boards (radar-equipped digital signs that tell drivers how fast they are moving),
  - high visibility crosswalks
  - new parking regulations
  - speed cameras

NYC SRTS Evaluation Program

- Data and Analysis
  - 186,000 geocoded pedestrian crashes 2001-2010
  - Geocoded school centroids
  - Census tract injury counts
    - Mon-Fri, 7AM-9AM or 2PM-4PM (excluding Summer, Holidays)
  - Compare SRTS census tracts vs non-SRTS census tracts pre and post program implementation (2008)

Results

- 44% decrease (95% CI 17%,65%) in SRTS census tracts following program implementation

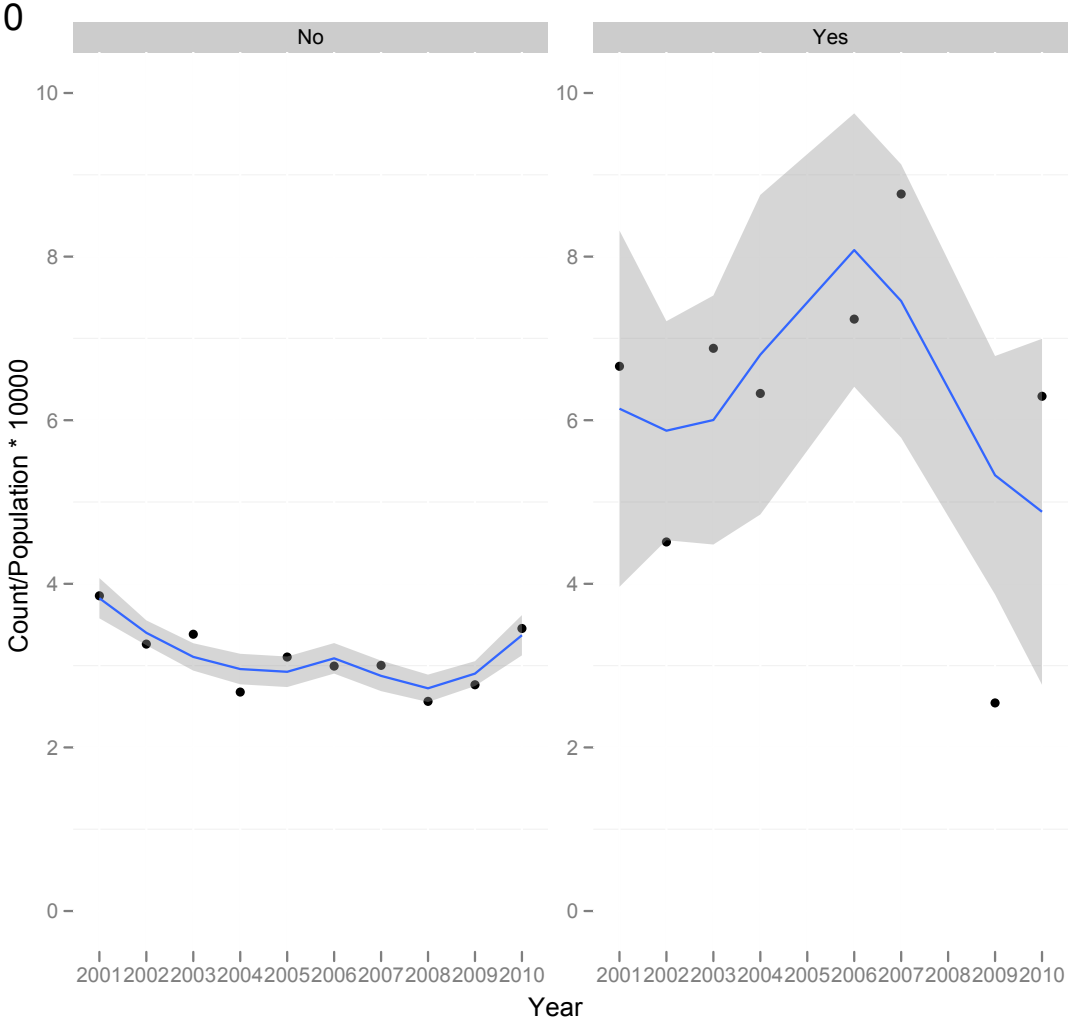
- 0% change (95% CI -8%, 8%) in non-SRTS census tracts following program implementation

PEDIATRICS
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Effectiveness of a Safe Routes to School Program in Preventing School-Aged Pedestrian Injury
Charles DiMaggio and Guohua Li
Pediatrics; originally published online January 14, 2013;
DOI: 10.1542/peds.2012-2182

Graphical Assessment

School-Aged Pedestrian Crashes per 10,000 Population During Travel To-From School Hours, SRTS Intervention Census Tracts (Yes) vs. Non-Intervention Census Tracts (No), New York City 2001-2010



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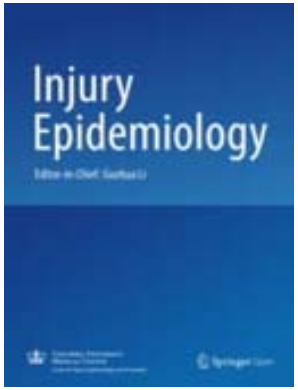
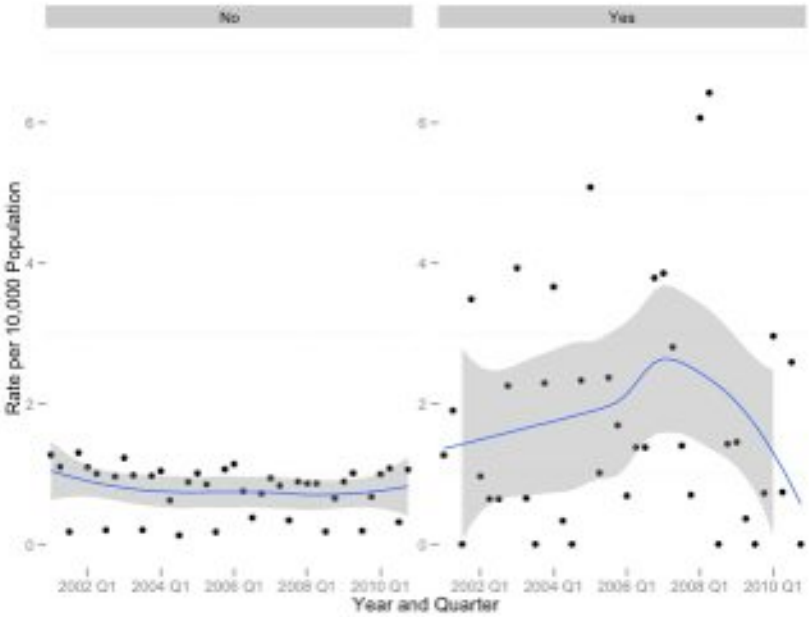
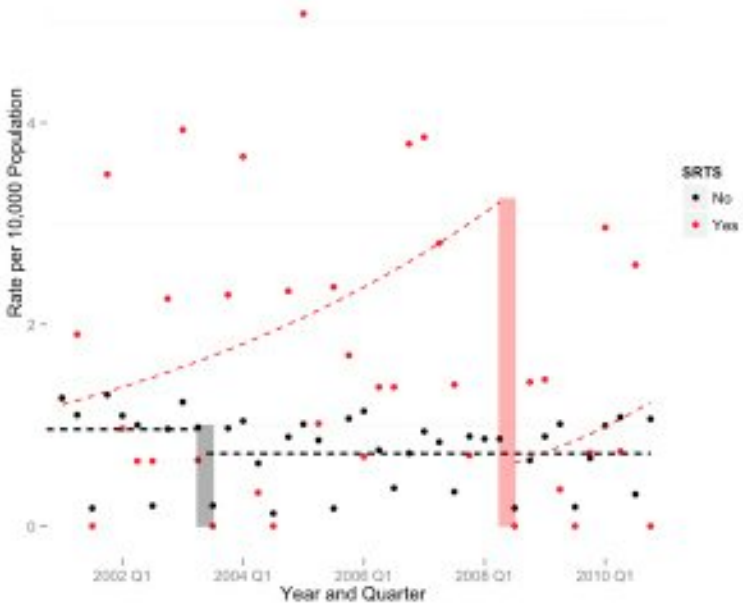
Changepoint Analysis

most likely changepoint SRTS census tracts 2nd quarter 2008 (quarter 30.5, 95% Cr I 30, 31)

non-SRTS census tracts largely unchanged







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Difference in Differences Analysis

$$\log(\mu_t) = \beta_0 + \beta_1 \text{Period}_t + \beta_2 \text{SRTS} + \beta_3 \text{Period}_t\text{*SRTS} + \log(\text{Population}_t)$$

	SRTS Vs. No SRTS	Completed SRTS Vs. Not Completed SRTS
Variable		
β0 (Pre-Changepoint, Non-SRTS)	-9.43 (-9.55, -9.31)	-8.51 (-8.69, -8.33)
β1 (Pre-Changepoint, SRTS)	0.95 (0.42, 1.48)	0.03 (-0.32, 0.38)
β2 (Post-Changepoint, Non-SRTS)	-0.13 (-0.40, 0.14)	-0.33 (-0.76, 0.10)
β3 (Post-Changepoint, SRTS)	-0.58 (-2.01, 0.85)	-0.38 (-1.34, 0.58)

- 44% risk reduction (95% CI 87% decrease, 130% increase)
  - compared to incomplete SRTS: 32% risk reduction (95% CI 74% decrease, 78% increase)

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Cost Benefit / Effectiveness

- Markov model long-term impacts SRTS on injury reduction
  - savings medical costs, disability, death
- overall net societal benefit $230 million, 2,055 QALYs NYC
  - $9.2 million, 1,638 QALYs school-aged pedestrians
    - much of cost benefit from reduced school-bus use

American Journal of PUBLIC HEALTH

Muennig P, Epstein M, Li G and DiMaggio C

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What next?

- State-Level Analysis
  - Geocoded vs. County vs. State Level Data
    - Individual States and Multilevel Modeling
- National Analysis
  - US Department of Transportation SDS
    - Individual States: Arkansas, California, Iowa, Kansas, Kentucky, Maryland, Michigan, Minnesota, Missouri, Montana, Nebraska, New Mexico, New York, Ohio, Pennsylvania, South Carolina, Texas, Virginia, Washington, Wyoming…
- New York City
  - Spatial Temporal Analysis
    - Transportation Alternatives – Speed Cameras

Texas

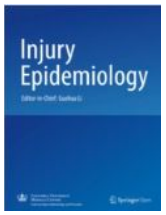
- 52,042 pedestrians and bicyclists struck and injured by motor vehicles in Texas between January 2008 and June 2013, aggregated quarterly

- age-group and pre-SRTS vs. post-SRTS time period (2010)

$$log(InjCount_i) = \beta_0 + \beta_1 * agegroup + \beta_2 * SRTS + \beta_3 * agegroup * SRTS + log(population)$$

- decline in rates
  - 42.5% (95% CI 39.6% to 45.4%) decline school-age pedestrian injury
  - 37.1% (95% CI 14.9% , 59.4%) decline school-age pedestrian injury fatality

- decline in risk
  - 14% reduction in school-age pedestrian and bicyclist injury risk (adjusted IRR 0.86, 95% CI 0.75 - 0.99)
  - 10% reduction in pedestrian and bicyclist fatality risk (adjusted IRR 0.90, 95% CI: 0.67, 1.21)



DiMaggio C, Brady J, Li G. Association of the Safe Routes to School program with school-age pedestrian and bicyclist injury risk in Texas. Injury Epidemiology. 2015. 2:15 doi:10.1186/s40621-015-0038-3

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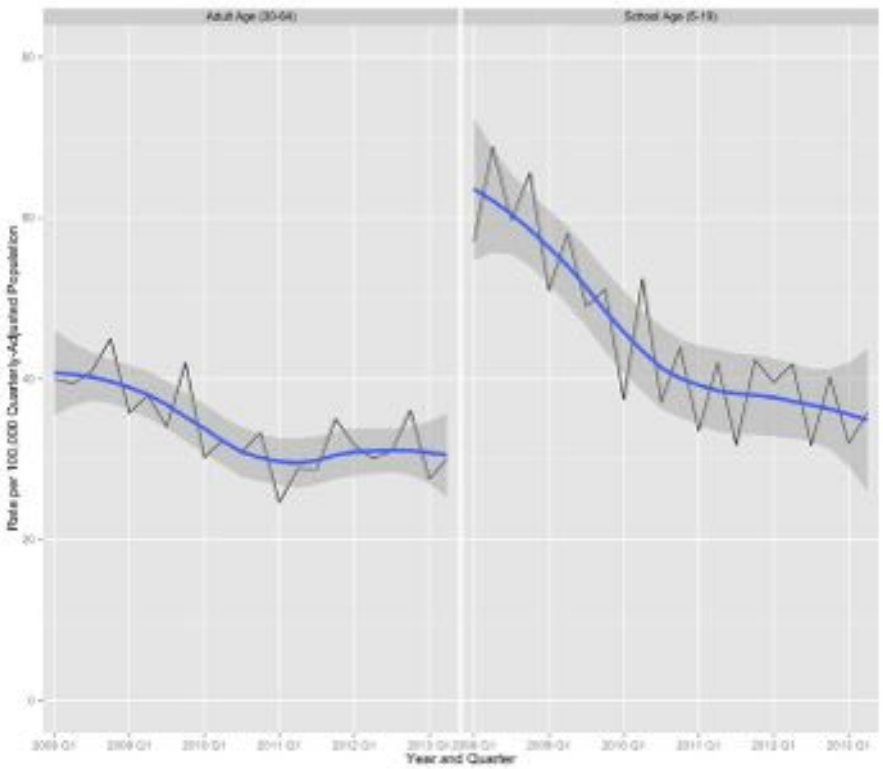
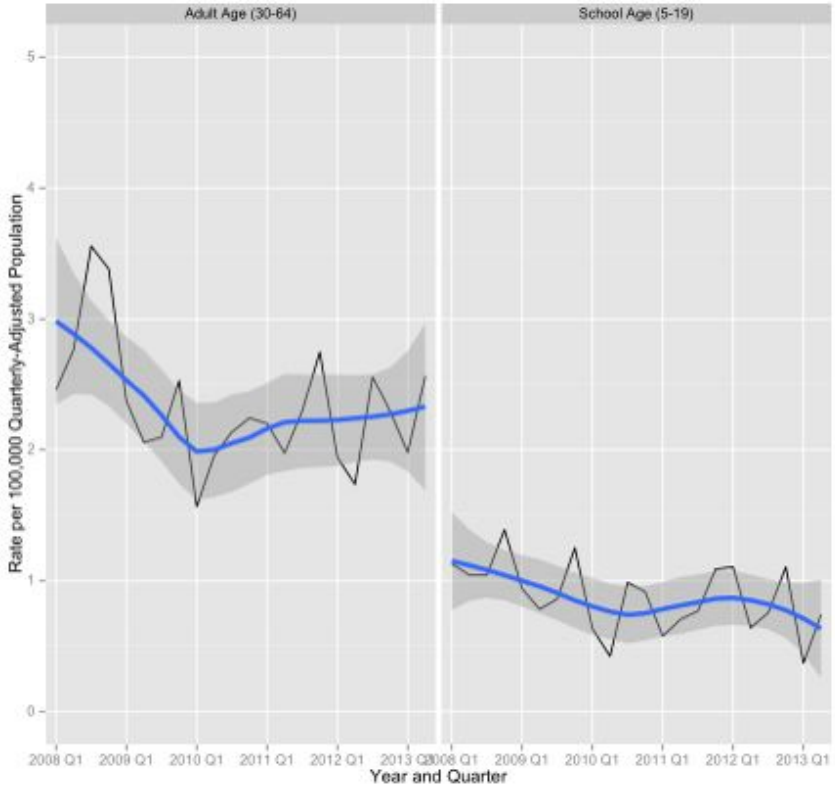
Texas Statewide Time Series



Adult vs. School-Age Injury Rates per 100,00



Adult vs. School-Age Fatality Rates per 100,00

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National SRTS Analysis

Data from 18 states representing 55% of the nation's 62 million school-age children over a 16-year period (AR, CA, CT, FL, IL, KS, KY, MD, MI, MO, NE, NM, NY, OH, PA, SC, VA, WA, 1995–2010)

Varying Intercept, Varying Slope, Multilevel Model based on Texas analysis (Added SRTS spending, % Roads Urban, Changepoint year set to 2007)

School-age children compared to adults aged 30-64 years

SRTS associated with an approximately 23% reduction in pedestrian/ bicyclist injury risk (IRR= 0.77, 95% CI= 0.65-0.92)

20% reduction in pedestrian/bicyclist fatality risk (IRR= 0.80, 95% CI= 0.68-0.94) in.

DiMaggio C, Frangos S, Li G. National Safe Routes to School program and risk of school-age pedestrian and bicyclist injury. Annals of Epidemiology. 2016 June; 26 (6): 412–417.

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National SRTS Evaluation

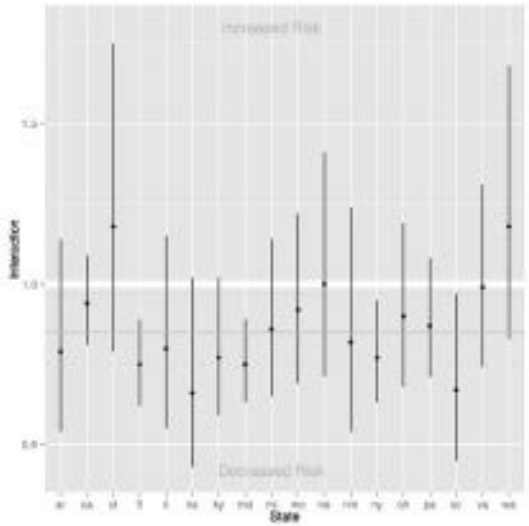

Figure 1: Non-Pooled, Individual State-Level Interaction Effects, Pre-Post 2007 Safe Routes to School Intervention Time Period by School-Age vs Adult. (Complete Pooled Estimate with 95% Confidence Intervals Overlaid in Light Grey)

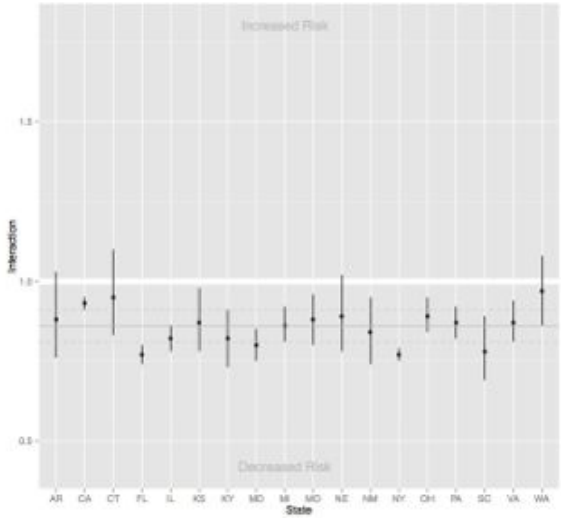

Figure 3: State-Level Point Estimates and 95% Confidence Intervals for Interaction Between Time Period and Age. Varying-Intercept, Varying Slope Multilevel Model of Effect of Safe Routes to School on School-Hour, School-Age Pedestrian Injury.

State-Level (Random) Effects

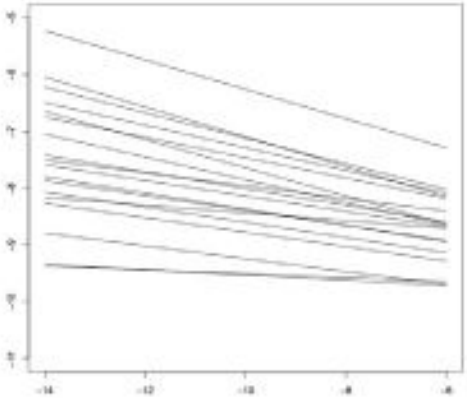

Figure 5: State-Level Slopes (Holding All Other Variables Constant) for Interaction Between Time Period and Age. Varying-Intercept, Varying Slope Multilevel Model of Effect of Safe Routes to School on School-Hour, School-Age Pedestrian Injury.

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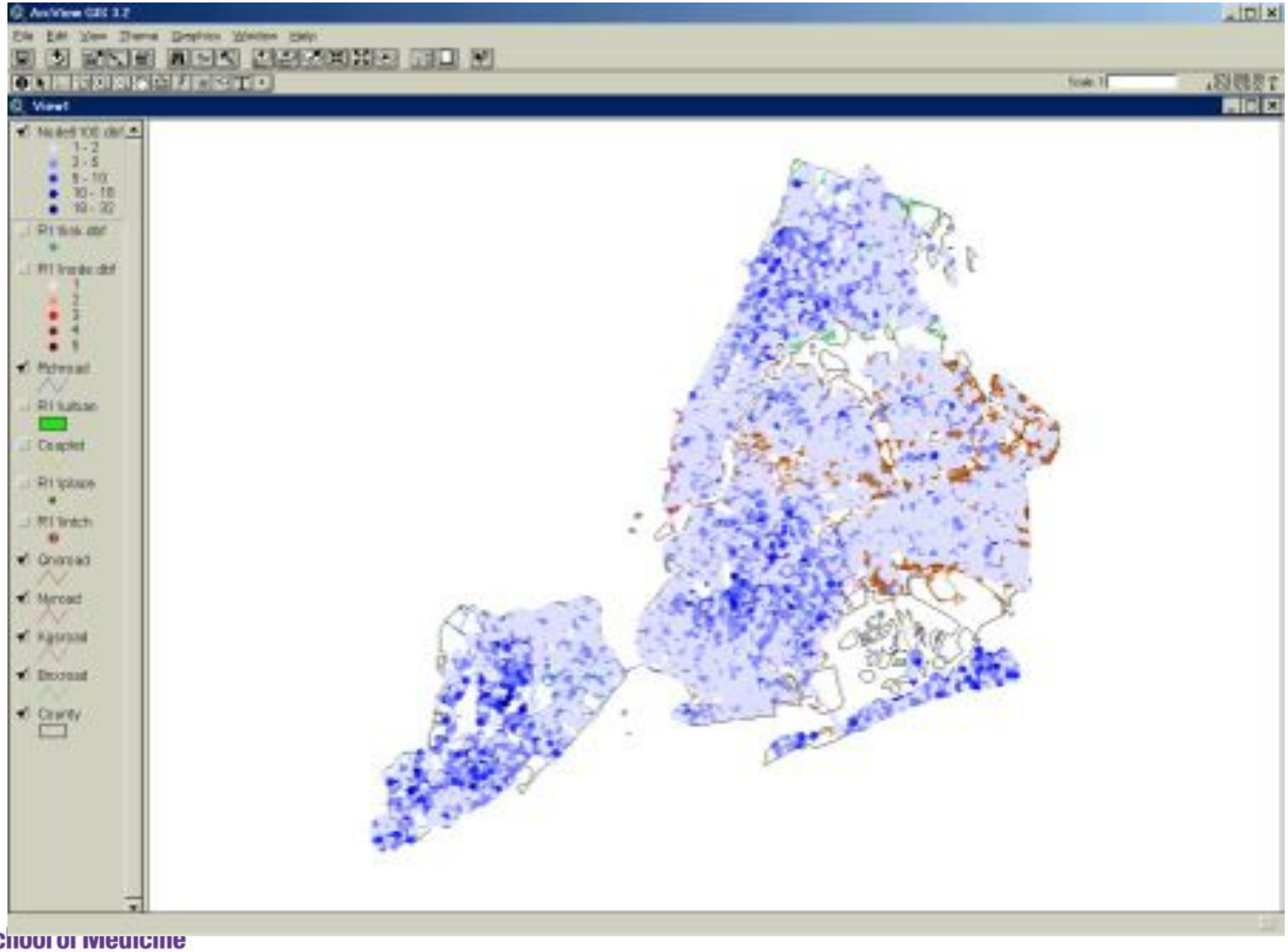
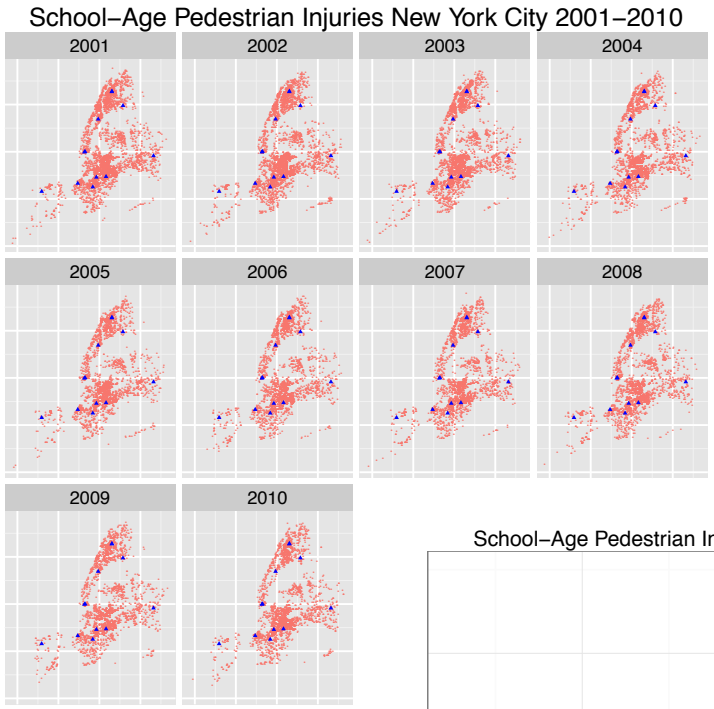
Back to Spatial Analysis

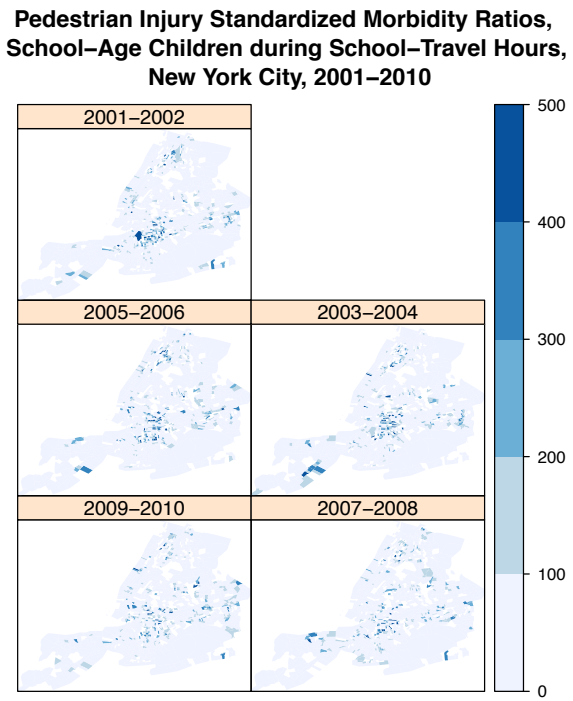


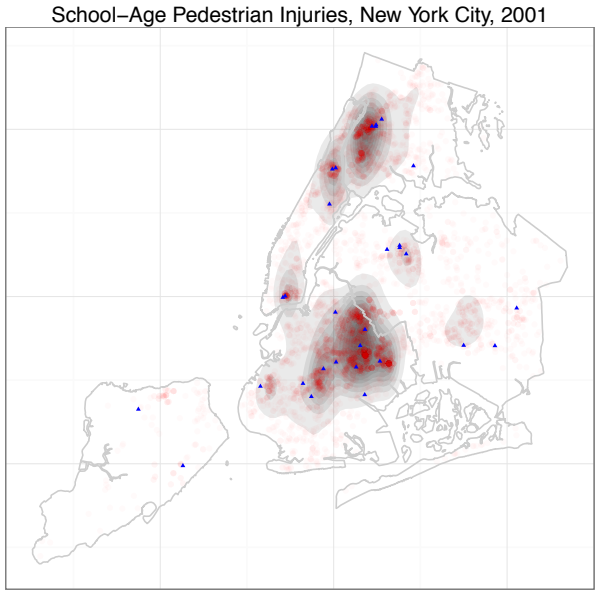
New Times, New Tools

Spatial Analysis SRTS

Spatiotemporal Models (BHM CAR): WinBUGS vs. Stan vs. INLA







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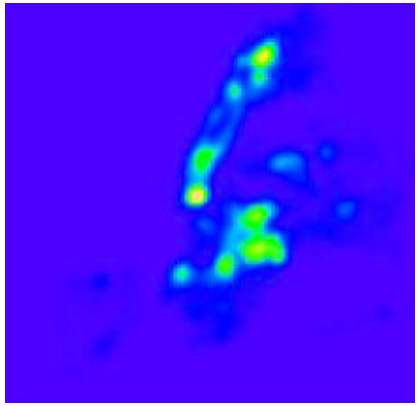
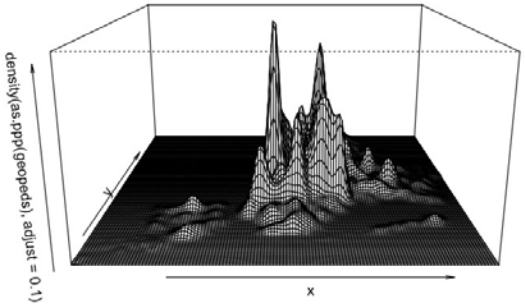
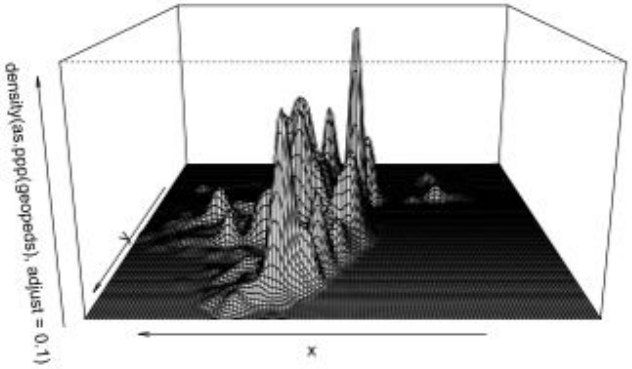
Spatial Analyses NYC







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Small Area Spatiotemporal Analysis NYC

All-age, all-hour injuries at Census Tract Level, 2001-2010
Model *Spatial Risk* with "Convolution Model" using Integrated Nested Laplace Approximations (rINLA)

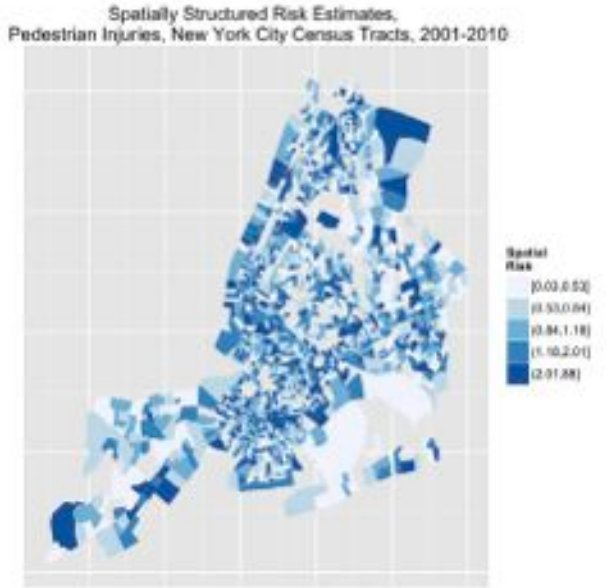
*log(injuries) = β_0 + β_1 social fragmentation (Congdon index) + β_2 income ($1000 MHI) + β_3 average speed (10 MPH) + β_4 traffic density (Standardized) + Unstructured Heterogeneity (RE) + Spatially Structured Heterogeneity (CAR) + First-Order Random Walk (year) + Interaction (place*time) + log (population)*

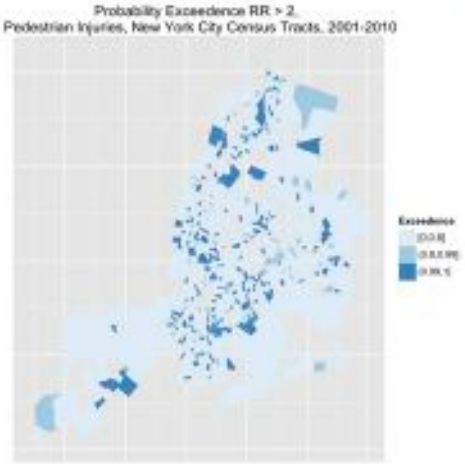
	Mean	SD	0.025 Quantile	0.975 Quantile
Intercept	0.00	1.13	0.00	0.00
Social Fragmentation	1.19	1.02	1.16	1.23
Median Household Income	1.00	1.00	1.00	1.00
Traffic Density	1.21	1.02	1.16	1.26
Average Speed	0.76	1.05	0.69	0.83

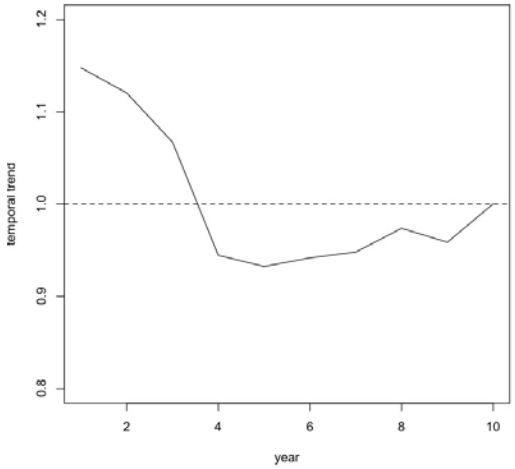
Table 1: Results of Spatiotemporal Model of Pedestrian Injury Risk, New York City, 2001-2010

- *Most of decline took place 200-2004*
- *Some census tracts did not benefit or had sporadic "outbreaks"*
- *70% of risk at spatial level (proportion variance due to CAR…)*

Small Area Spatial-Temporal Analysis NYC







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Large Data Sets

- AHRQ HCUP NEDS
  - 20% Sample; 198,102,435 observations, 2006-2012, ~ 100 variables
- 467,093 ED discharges (95% CI 464,110; 470,076) Ped/Cyclist MVCs <19 y/o
  - 19.3% decline ED discharges (95% CI 16.8, 21.8) over the study period
  - 24.8% (95% CI 17.8, 31.9) decline population-based ED fatalities
    - 14.0% decline ED CFR
- TBI
  - 6.7% (95% CI 6.3, 7.1) of these discharges, but 55.5% (95% CI 27.9, 83.1) of fatalities
  - accounted for 49.1% (95% CI 38.4, 59.4) of the excess mortality in pedestrians vs. cyclists
    - $IC = (Risk_{ped+TBI+} - Risk_{ped-TBI-})$
      $= (Risk_{ped+TBI-} - Risk_{ped-TBI-}) + (Risk_{ped-TBI+} - Risk_{ped-TBI-})$.

(Working with) Large Data Sets (in R)

- Old ROT for R: 100K obs, 20 Var will fit RAM, but things have changed
  - https://www.r-bloggers.com/five-ways-to-handle-big-data-in-r/
  - http://www.columbia.edu/~sjm2186/EPIC_R/EPIC_R_BigData.pdf
- External databases for even larger files
- MonetDB (Column Oriented)
  - https://www.monetdb.org/blog/monetdblite-r
  - http://www.injuryepi.org/resources/Misc/hcupNotesMonet.pdf

Some Conclusions

- Traffic Calming Works
  - expensive, but we can rationally and effectively use public resources to address public health and safety
  - education and enforcement still important
- Kids can still be kids and be safe. (And so can adults.)
- Evaluation Important
  - MAP-21 removes SRTS as stand-alone program
  - difficult to tease out effects of any single program
    - 1500 pedestrian signals, re-engineered 60 miles of streets, 20 MPH pedestrian safety zones
  - Tools and methods getting better
  - Documentation also important
    - Share your code –
    - http://www.injuryepi.org/resources/spatial/inlaEpidemCode.pdf