Exploring Delinquency in High Risk Students using Longitudinal Zero-Inflated Poisson Bayesian models

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Introduction/Background

- Deliquency emerges in the lower grades, peaks in middle and high school, and declines in adulthood[1]
- It has been associated with poor parental supervision, violent parents, child abuse, low family income, peer delinquency and academic failure[2]
- High risk students face additional stresses that may increase deliquency:
  - They experience higher parental distress, cumulative risk stress, depression, and higher exposure to adversity[3]
  - This heightened stress can carry over and negatively impact achievement and behavior
- Suspensions from school are one measure for assessing childhood deliquency
- Most studies have been cross-sectional or not accounted for correlations associated with repeated measurements or nesting of students in school
- How to deal with a longitudinal outcome measure were majority of the students have no suspensions?

Research Questions

- Does suspensions follow a similar growth trajectory to other delinquent behaviors and is there a risk gradient?
- Is there a development component to suspensions? Do trajectories and timing differ by gender and gender by ethnicity interactions?
- Do models that account for zero-inflation fit better than traditional Poisson models?

Methods

Sample

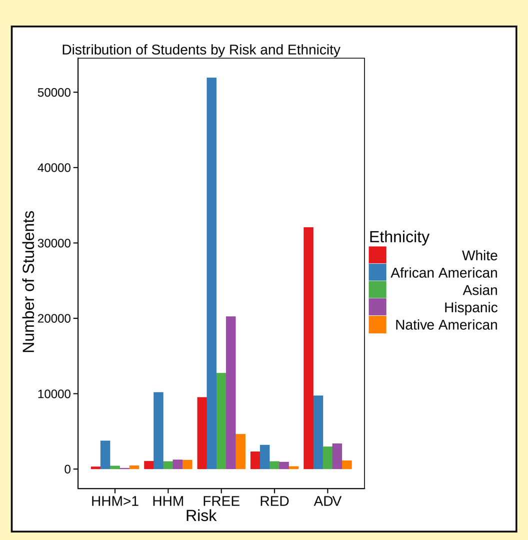
- Data were collected by Minneapolis Public Schools
  - 81,724 students in grades 1 - 12
  - 175,975 data points
  - All students included in study had complete data on the independent variables

Risk Classification

- HHM > 1 - Students were homeless or highly mobile (HHM) more than once
- HHM - Students were HHM only once
- FREE - Students were on free lunch but not HHM
- RED - Students were on reduced-priced lunch but not HHM
- ADV - Neither HHM nor FREE or RED

Descriptives

- 127 schools examined
- Males and females evenly distributed through risk groups
- Special education ranges from 34% in HHM > 1 to 10% in ADV.
- 86% of all data points are zeros.
  - 72%, in HHM > 1, 77% in HHM, 83% in FREE, 89% in RED, and 96% in ADV



Statistical Methods/Analysis

Zero-Inflated Poisson Models (ZIP)

- Poisson and ZIP Bayesian multilevel models were examined
  - ZIP models are mixture models consisting of a zero-inflation and Poisson component
  - Zeros arise from both components
  - Complex model
    - Requires MCMC burn-in of 10,000 and 60,000 iterations to converge!
    - Estimates parameters for binomial (zero-inflated) and Poisson components
    - Requires specification of a prior on B-, G-, and R- structures
    - However, G-structure is fixed because residual can not be estimated with binomial models but R-structure highly suspectible to priors

Analysis: Question 1

- To answer question 1, ZIP multilevel quadratic models with covariate-intercept interactions were examined
- Included a school level effect (i.e. nesting of students within school).
  - Flat prior on B-structure ($\mu = 0$; $\sigma^2 = 1e10$)
  - Prior on G-struture was fixed
  - R-structure had a flat inverse-Wishart prior ($\nu = 1$; $V = 1$) with Cauchy parameter expansion ($\mu = 0$; $\sigma^2 = 25^2$)
- Compared growth curve to other deliquent behaviors and examined Bayesian confidence intervals and posterior models

Analysis: Question 2

- Examined timing and trajectories of males and females
  - If developmental, then females should have an earlier suspension crescendo
- Examined timing and trajectories of gender by ethnicity
  - If developmental, crescendo of Hispanic females should be first, followed by African American females

Analysis: Question 3

- Poisson and ZIP models
- Comparison of growth curves

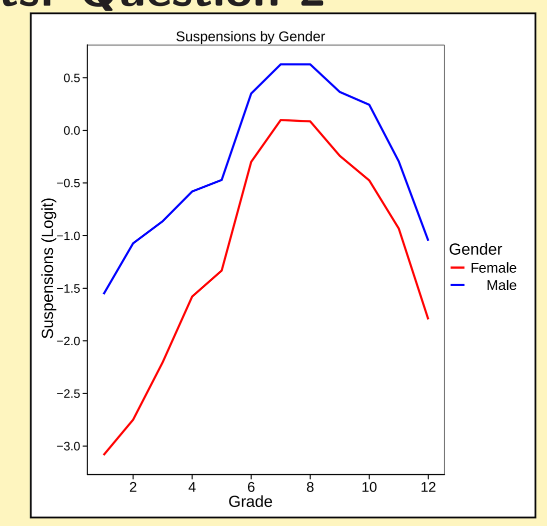
Results

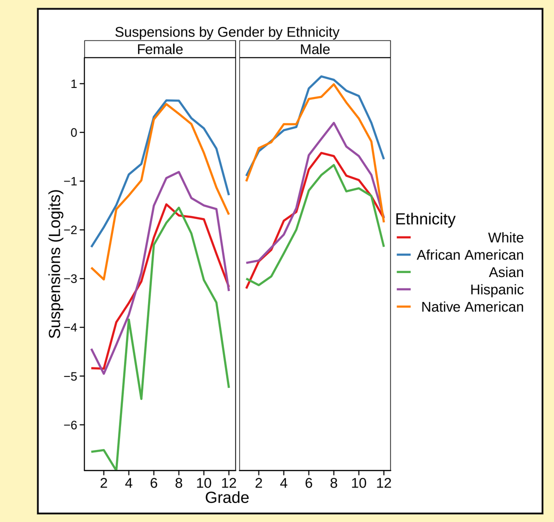
Results: Question 1

Parameter Estimates	Posterior Mode	95% Bayesian CI
HHM v. HHM > 1	-0.349	-0.456, -0.194
FREE v. HHM > 1	-0.606	-0.740, -0.491
RED v. HHM > 1	-1.127	-1.279, -0.946
ADV v. HHM > 1	-2.021	-2.15, -1.885
African American v. White	1.369	1.311, 1.475
Asian v. White	-1.404	-1.561, -1.302
Hispanic v. White	-0.114	-0.213, -0.013
Native American v. White	1.153	1.002, 1.252
Special Education	0.894	0.822, 0.938
Gender	1.032	0.979, 1.085
Grade	0.961	0.933, 1.002
Grade^2	-0.065	-0.067, -0.062

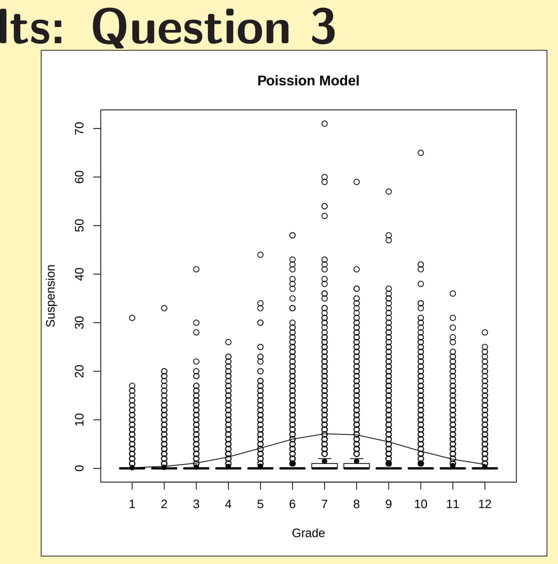
Results

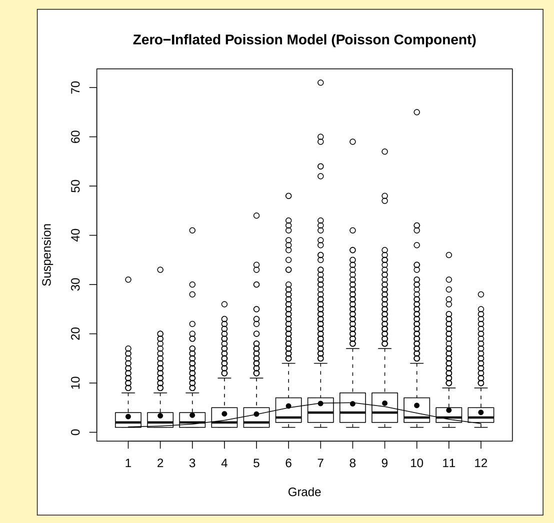
Results: Question 2





Results: Question 3





Conclusion

- Suspension showed similar growth trajectory to other deliquent behaviors
  - However, timing was earlier than other behaviors
  - Driven by policy but influenced by puberty?
- There was no difference in timing of crescendo for gender and gender by ethnicity interactions
- The ZIP and Poisson models appear to show no differences?
  - However, residual variance greater in Poisson than ZIP model and ZIP better predicts zeros!
  - More posterior predictive checks required
  - Both multilevel ZIP and Poisson required priors to converge, i.e. needed to use Bayesian statistics
    - Bayesian approaches widely accepted in other fields such as ecology and biostatistics
    - Can use sensitivity analysis to examine robustness of estimates under different priors
    - How should we deal with prior specification?
  - Future simulation work comparing ZIP v. Poisson models under myriad of scenarios

References/Acknowledgements

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