Analyzing continuous injury outcomes with quantile regression methods

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Presenter Disclosures

Cody S. Olsen

(1) The following personal financial relationships with commercial interests relevant to this presentation existed during the past 12 months:

No relationships to disclose

Outline

I. **The Problem:**
Non-normal continuous injury outcomes

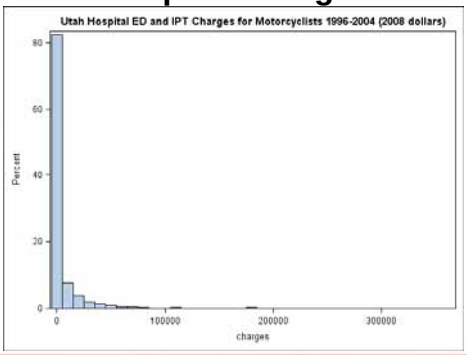
II. **A Solution:**
Quantile Regression

III. **An Application:**
Motorcyclist Hospital charges

Continuous injury outcomes

- Hospital Charges, Cost, Length of Stay
  - Commonly used continuous injury outcomes
  - Right skewed
  - Heterogeneous
  - Do not meet distributional assumptions

Hospital Charges



Analysis Options

Ordinary Least Squares (OLS) Regression

- Models the relationship between one or more covariates X and the *conditional mean* of a response variable Y given X=x
- Assumes errors are normally distributed
- Assumed link function of variance & mean
- May transform data to improve normality

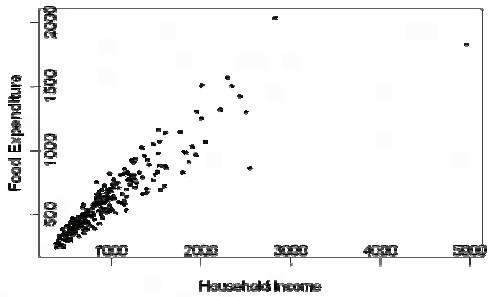
Quantile Regression

- Models the relationship between one or more covariates X and the *conditional quantile* of a response variable Y given X=x
  - *k^{th} Quantile:* the value at which k% of data are above, and 100-k% of the data are below
  - e.g. median, percentile, quartile, decile

Quantile Regression

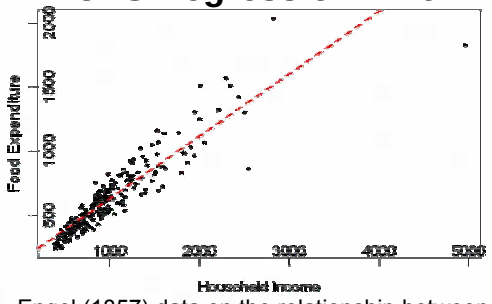
- No distributional assumptions about errors
- No link function relating variance & mean
- Equivariant to monotone transformations
- Gives standard errors and p-values
- Results may include a family of curves

What does it look like?



- Engel (1857) data on the relationship between food expenditure and household income

OLS Regression Line



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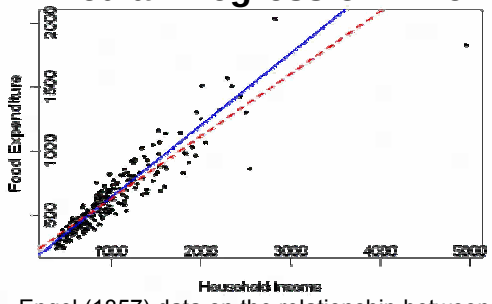
Median Regression Line



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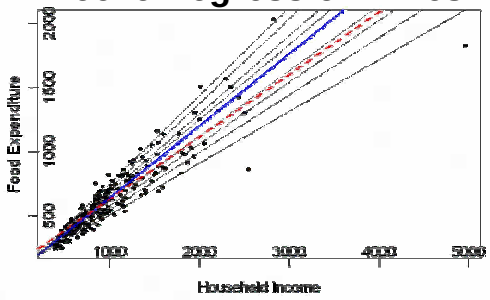
Decile Regression Lines



- Engel (1857) data on the relationship between food expenditure and household income

Example: Hospital charges for motorcycle operators involved in a crash

Research Questions

- Does helmet use reduce hospital charges for motorcyclists involved in a crash?
- What factors are associated with an increase in hospital charges?

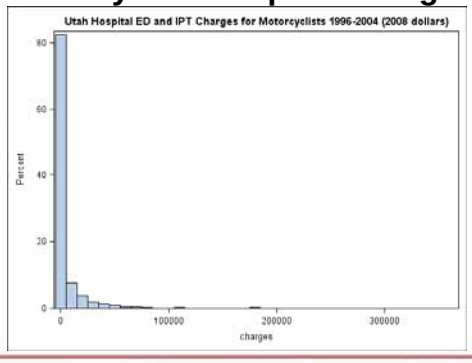
Motorcycle Hospital Charges

- Utah emergency department and inpatient charges for motorcycle operators in a crash (1996 -2004)
- Crash and hospital data linked
- $0 charges assigned to non-linked
- Fatalities excluded
- Missing data imputed
- Combined results from 5 imputed sets

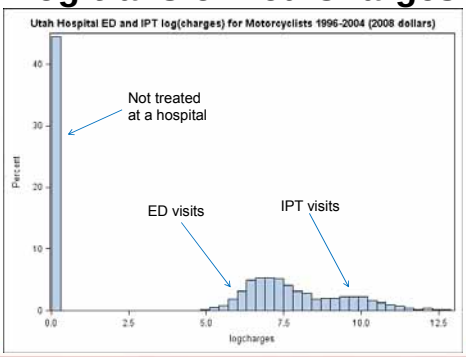
Motorcyclist Data

- 4,386 motorcycle operators
- Helmet Use: 69%
- Single Vehicle Crash: 76%
- Rural Crash: 42%
- Median Age (IQR): 29 years (22, 44)
- ED or Inpatient visit: 56%
- Average Charges: $6,166

Motorcyclist Hospital Charges



Log-transformed Charges



Quantile Regression Models

- Response: Total Hospital Charges
- Predictors:
  - Helmet Use
  - Single Vehicle Crash
  - Rural Crash
  - Age and Age^2
    29 years as reference

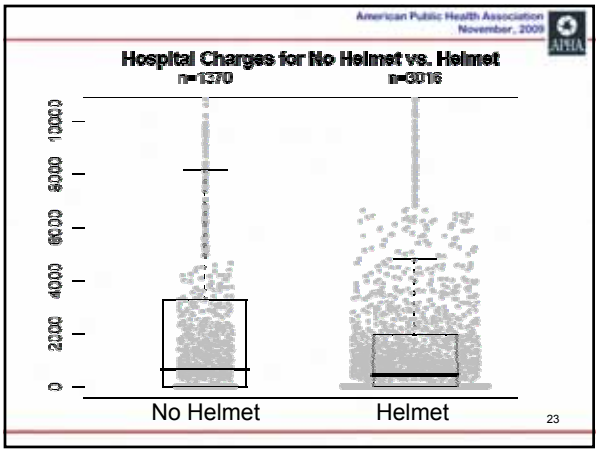
Results: median charges

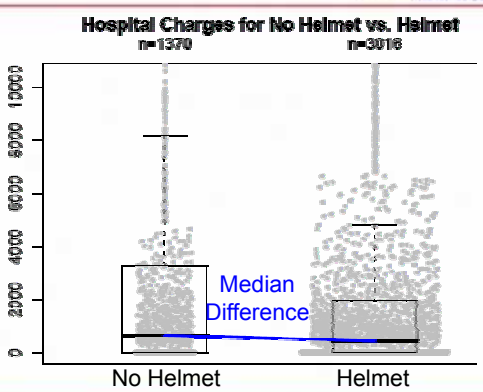
Parameter	*Coefficient*	*95% CI*
Intercept	$320	(180, 460)
Helmet	− $246	(-396, -97)
Single Vehicle	+ $437	(348, 526)
Rural	+ $168	(51, 285)
Age	+ $7.43	(1.68,13.2)
Age^2	− $0.22	(-.44, -.004)

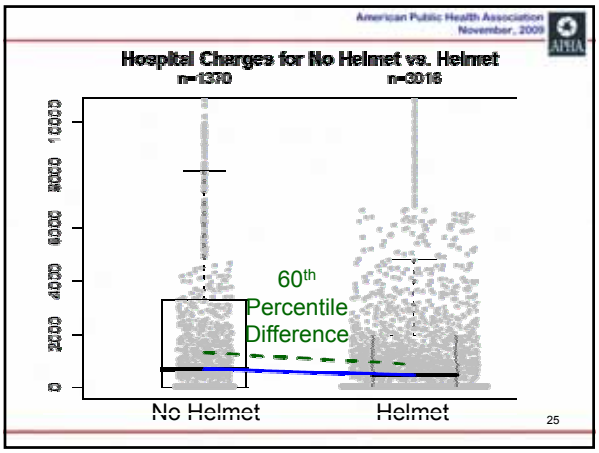
Upper quantiles

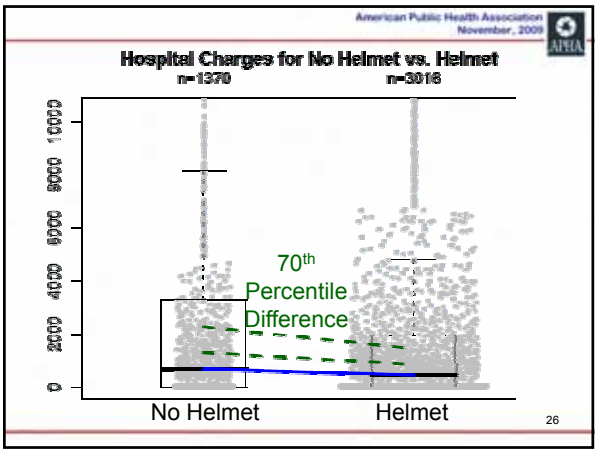
Percentile	Charges Without Helmet	Difference w/ Helmet
50th	$320	− $246
60th	$774	− $471
70th	$1625	− $896
80th	$4150	− $2112

- 29 year-old, multiple-vehicle, urban crash, dry conditions






American Public Health Association
November, 2009
Hospital Charges for No Helmet vs. Helmet
n=1370
n=3016
60th
Percentile
Difference
No Helmet
Helmet
25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Hospital Charges for No Helmet vs. Helmet
n=1370
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Percentile
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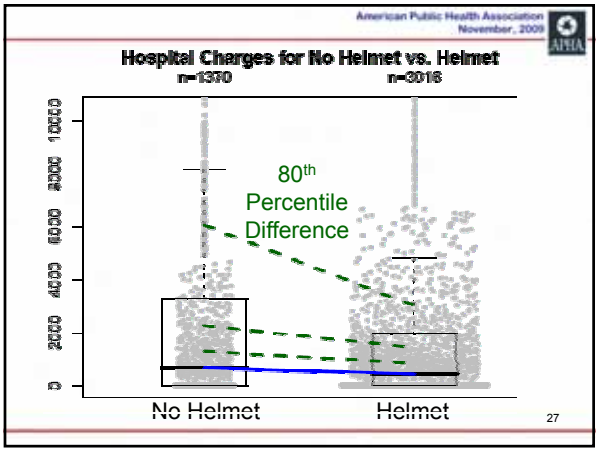
Helmet
26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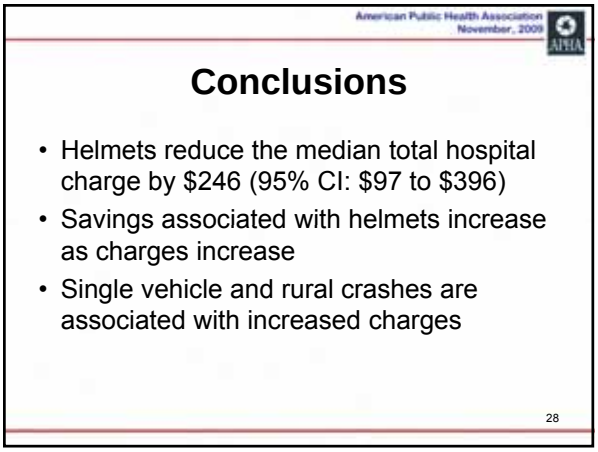
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Conclusions
• Helmets reduce the median total hospital charge by $246 (95% CI: $97 to $396)
• Savings associated with helmets increase as charges increase
• Single vehicle and rural crashes are associated with increased charges
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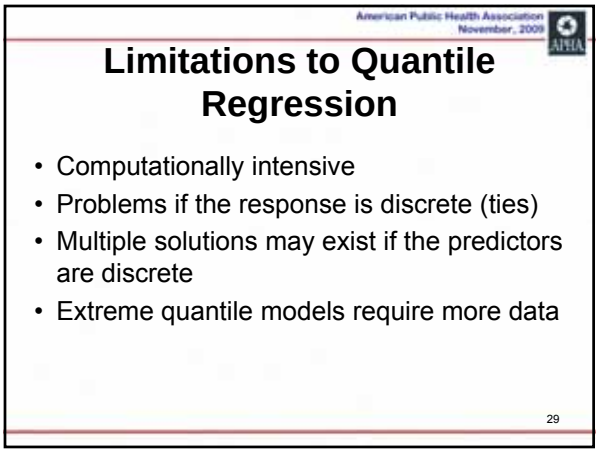
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Limitations to Quantile Regression
• Computationally intensive
• Problems if the response is discrete (ties)
• Multiple solutions may exist if the predictors are discrete
• Extreme quantile models require more data
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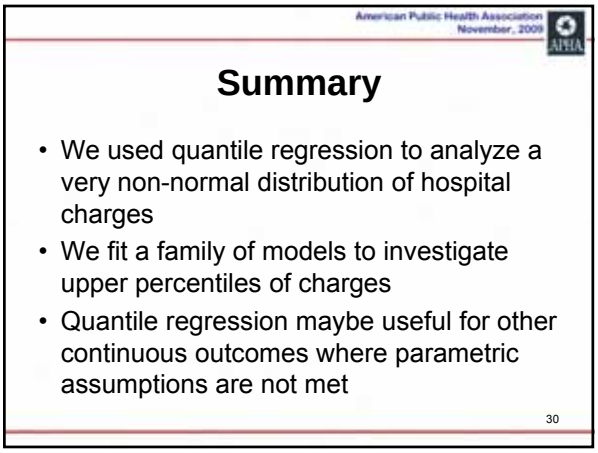
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Summary
• We used quantile regression to analyze a very non-normal distribution of hospital charges
• We fit a family of models to investigate upper percentiles of charges
• Quantile regression maybe useful for other continuous outcomes where parametric assumptions are not met
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Questions

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