Water and Sewer Service Disparities in North Carolina

Public Health Implications

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Water and Sanitation Service Led to 20th Century Public Health Gains

Death Rate for Typhoid Fever
United States, 1900-1960

Chlorination Begun

New York Times, 2005:

“Golf has made Moore County rich. . . .

But as developers rush to provide ‘resort quality’ amenities in the newest subdivisions, some neighborhoods have been left behind—without sewers, police service, garbage pickup, or . . . piped water.”
Some Unserved Communities Border Municipal Utility Pipes

Moore County (Pinehurst) example:

Irregular city boundaries exclude minority communities

Source: Cedar Grove Institute for Sustainable Communities
Magnitude of Service Disparities Problem Is Unknown

• Survey asked all 100 NC county health directors to quantify service disparities.
  - Only 39 responded.
  - Provided qualitative rather than quantitative descriptions.
Example Survey Responses

Pitt County

“Homes with privies, straight-pipes, failing drain fields, or incomplete plumbing.
Severely limited soils with high water table.”

Stokes County

“Clusters of homes with insufficient or failing septic systems.
Residences with cistern, spring, or no piped water to home.
Clusters of homes with no available space remaining to install a replacement septic system or replacement well.”
Long-Term Objectives

• Assess extent of water and sewer service disparities in North Carolina.

• Characterize health benefits of extending water and sewer services.

• Identify factors influencing decisions to extend or not extend services.
Focus on “Extraterritorial Jurisdictions” (ETJs)

Progress Report (Today’s Talk)

1. Extent of disparities:
   - Mapping affected communities in Wake County
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2. Health risks and benefits:
   - Private well testing in Wake County
   - State-wide private well health risk analysis
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3. Factors influencing decisions
   - Case studies in three communities
Project 1: Map Affected Communities In Wake County

Questions:

1. Where are underserved communities in Wake County extraterritorial jurisdictions located?

2. Is race a significant factor in predicting water and sewer access in Wake County extraterritorial jurisdictions?
Data Sources

Two data sources:

1. County-level tax parcel data
2. State-wide U.S. Census data
   - Water and sewer service data not available after 1990
Analysis Method: Logistic Regression

What factors predict “odds” of water service in a random census block in an extraterritorial jurisdiction?

\[
\text{Odds} = \frac{P(\text{no water service})}{P(\text{water service})}
\]

Analyze significance of explanatory factors with “logistic regression:”

\[
\ln(\text{Odds}) = \beta_0 + \beta_1 \times \%\text{Black} + \beta_2 \times \text{Income}
\]
Results: Tax Data Reveal Unserved Wake County Areas
Close-Up Views Reveal “Donut Holes” Lacking Water Service
Descriptive Data Suggest Race Is Associated with Water Access
Logistic Regression Shows Race Is Significantly Associated with Water Access

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p Value</th>
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<tbody>
<tr>
<td>Intercept</td>
<td>-0.57</td>
<td>0.0001</td>
</tr>
<tr>
<td>%Black</td>
<td>0.36</td>
<td>0.05</td>
</tr>
<tr>
<td>Income</td>
<td>$6.1 \times 10^{-7}$</td>
<td>0.72</td>
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</table>

Income is NOT a significant predictor of water service access.

Interpretation: Every 10% increase in Black population increases odds of being without water service by $\exp(0.1 \times 0.36) = 1.037$ (3.7% increase).
Project 2: Benefits of Extending Municipal Services

What are the benefits of extending municipal water service to under-served areas?

- State-wide analysis using existing data
- (Wake County well sampling in ETJs)

E.M. Johnson water treatment plant, Raleigh. Photo: Hazen & Sawyer
State-Wide Analysis

Overall approach: “Population intervention model”

Seeks to answer the question: “What if exposure to a risk factor were modified in some portion of the population?”
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Backyard Wells  Municipal Water Service
State-Wide Analysis

Overall approach: “Population intervention model”

Seeks to answer the question: “What if exposure to a risk factor were modified in some portion of the population?”

Backyard Wells

Municipal Water Service
Regression Establishes Link Between Health Outcome and Exposure

Regression equation for population intervention model:

\[ Y_{i,j} = \beta_0 + \beta_1 C_{CWS_{i,j}} + \beta_2 E_{CWS_{i,j}} + \beta_3 C_{DWS_i} + \text{other factors} \]

- **Acute gastrointestinal illness (AGI) cases in county \( i \), month \( j \)**
- **Coliform bacteria in community water systems**
- **Coliform bacteria in private wells**
Regression Establishes Link Between Health Outcome and Exposure

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Data Sources

Health Outcome Data
• Emergency department visits for acute gastrointestinal illness (AGI) in all NC emergency departments (n=122)
  – 2007-2013

Water Quality Data
• Community water systems: Reported compliance samples for the total coliform rule
  – 2006-2013
• Domestic wells: Private well permit program coliform sampling results
  – 2009-2013
Wake County Water Quality Analysis

- Sampling in 100 homes selected at random from “red” blocks
- Testing for indicators of fecal contamination:
  - Total coliform bacteria
  - E. coli
  - Enterococci
State-Wide Analysis Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta</th>
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<tbody>
<tr>
<td>Total coliforms in community water systems</td>
<td>0.0000671**</td>
</tr>
<tr>
<td>E. coli in community systems</td>
<td>0.000163*</td>
</tr>
<tr>
<td>Private well contamination</td>
<td>0.0044**</td>
</tr>
<tr>
<td>Population</td>
<td>0.0012**</td>
</tr>
<tr>
<td>Poverty</td>
<td>0.0077**</td>
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Microbial contamination of private wells is significantly associated with emergency department visits for AGI.
12% of AGI ED Visits Are Attributable to Lack of Water Service

- Other causes, 88%
- Domestic wells, 12%
- Community water systems, 0%
Risks Vary by County

Annual ED Visits per 1,000 People for AGI attributable to DWSs

High: 26
Low: 0.4
Extending Water Service to Private Well Users Would Prevent ED Visits

• 46,700 annual ED visits attributed to private well contamination.
• Cost = $51 million/year.
• Every 10% shift in population from private to community systems is expected to decrease ED visits for AGI by 1.6%.
Locations of Wake County Homes Participating in Sampling
Wake County Preliminary Results

First samples: 29% positive for total coliforms (n=59)

Second samples: 39% positive (n=46)

- Community systems in violation of Safe Drinking Water Act if more than 5% of samples are positive
Project 3: Factors Influencing Decision to Extend Water Service

Method:

- Key informant interviews in three communities
- Transcribe interviews, and code using Atlas.ti software
- Identify common themes
Variety of Perspectives Sought

Total Participants (25)

- Elected (4)
  - County (3)
    - County Commissioner (3)
  - City (1)
    - Mayor (1)
- Non-Elected (21)
  - Government (14)
  - Non-Government (7)
    - Public Utility Authority (1)
    - Community Members (6)
- County (9)
  - County Manager (1)
  - Planning Director (2)
  - Health Official (4)
  - City Utility Provider (4)
  - City Manager (1)
Summary

• Mapping reveals that racial disparities in water service may persist in extraterritorial jurisdictions in Wake County.
  - Increasing black population decreases odds of water service availability in census block.

• Water sampling suggests poor water quality in some domestic wells is associated with increased emergency department visits for AGI.
  - Nearly 12% of emergency department visits for AGI are attributable to domestic well contamination.

• Key informants suggest cost is key barrier to extending services.
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Questions?