Spatial and temporal patterns of gastrointestinal illness and their relationship with precipitation across the state of North Carolina

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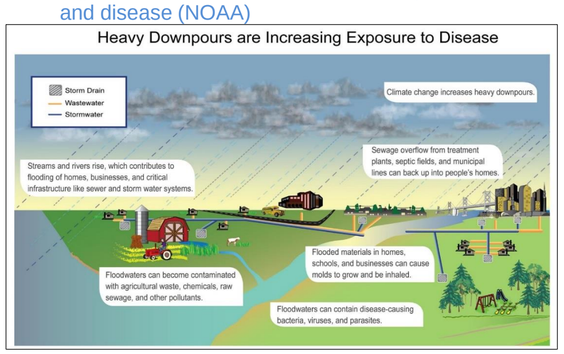
INTRODUCTION

The quality of drinking water quality in the US is among the best in the world; however, pathogens are present in source waters that are used for drinking water. Water and floodwaters specifically can spread pathogens within watersheds by mobilizing pathogens and transporting them. Previous research has identified an association between gastrointestinal (GI) illness and heavy precipitation (Curriero et al., 2001 and Figure 1).

OVERALL STUDY OBJECTIVE

This study analyzes patterns of GI illness and their relationship with various demographic variables and precipitation across the state of North Carolina from 2008-2012.

Figure 1. Relationships between heavy downpours and disease (NOAA)



METHODS: ICD-9-CM CODES

ICD-9-CM codes (Table 1) from Emergency Department (ED) visits in NC hospitals were extracted from the NC DETECT database (NC Disease Event Tracking and Epidemiologic Collection Tool). NC DETECT is North Carolina's statewide syndromic surveillance system.

ICD-9-CM	Disease
001-009	Intestinal infectious diseases
558.9	Non-specified gastrointestinal illness
787.91	Diarrhea (not otherwise specified)

Table 1. ICD-9-CM codes utilized for case definition in this study. Codes 001-009 include cholera (001), salmonella (003), and norovirus (008.63), among others.

METHODS: DATA SOURCES

ED data include patient information such as ZIP code of residence, gender, and age. Precipitation totals were collected from the nearest weather…

METHODS: DATA SOURCES continued

…station maintained by a government organization to the ZIP code of residence. Demographic factors were collected both on the ZIP code and county levels from the US Census Bureau. Drinking water source data at the county level was collected from a previous UNC-CH study by Luh et al., 2015.

METHODS: LAG PERIODS AND PRECIPITATION

Using a 3-day and a 10-day lag period, the total population of ED visits was split into two samples based on the cumulative amount of precipitation (Table 2), wherein "heavy" rains were greater than 2 inches and "light" rains were less than 2 inches.

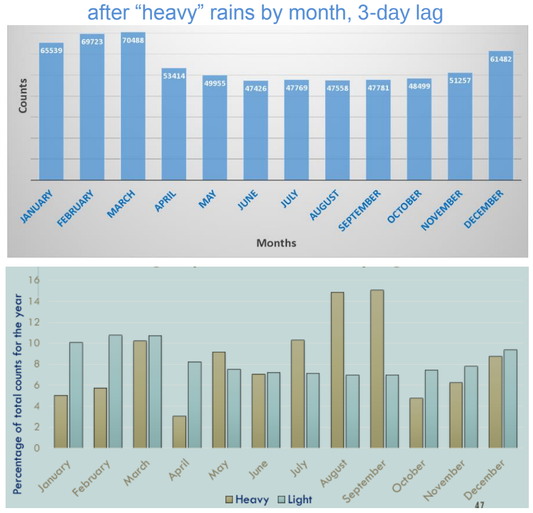
Lag Period	Precipitation threshold	Threshold in which precipitation considered to be in error
3-day	0.00"-2.00"	Any values >15.00"
10-day	0.00"-2.00"	Any values >25.00"

Table 2. Definitions of "light" precipitation for this study given 3-day and 10-day lag periods.

RESULTS: TEMPORAL

Overall ED visits show a peak in the winter months (Figure 2, top). However, given heavy rains in a 3-day lag, the signal for the year is different, with a peak in late summer months (Figure 2, bottom). Although not shown here, the 10-day lag after heavy rains presents the same summer-peak trend.

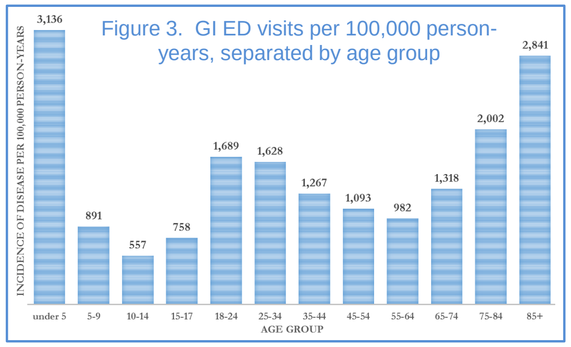
Figure 2. Top: Total counts of ED visits for AGI by Month; Bottom: Percentage of total counts for the year after "heavy" rains by month, 3-day lag



RESULTS: DEMOGRAPHIC

The youngest and oldest age groups are the most affected by GI illness (Figure 3), which aligns with results from previous studies (Drayna et al. 2010).

Figure 3. GI ED visits per 100,000 person-years, separated by age group



Correlations were run for multiple variables (only a few of which are shown below, other variables that were excluded from this chart but still part of the study included rurality of county, population density per county, and seasonality (high vs. low viral seasons to account for potential norovirus), among others). The highest correlation values are between poverty and disease rates (Table 3).

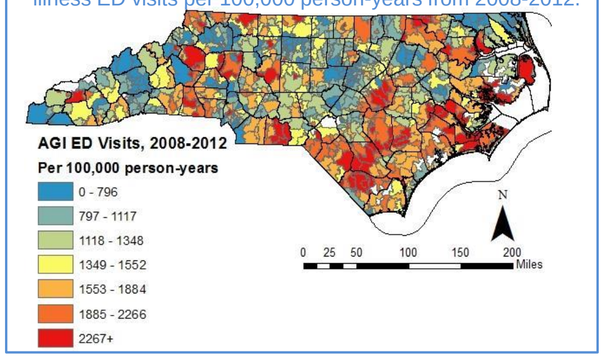
Factor (at the county-level)	Disease Rates
Avg. Household Size	0.02
% under 18 in poverty	***0.40**
% 18-64 in poverty	***0.24**
% 65+ in poverty	***0.30**
Percent Minority	***0.22**
Self-supplied Drinking Water (DW)	-0.06
Very Small/Small Community DW	0.04
Large/Very Large Community DW	0.03
% no health insurance	***0.23**
% no or public health insurance	***0.35**
% with health insurance	-0.21

Table 3. Correlations for rates of gastrointestinal illness per 100,000 person-years and demographic variables. A * represents statistical significance.

RESULTS: SPATIAL

Spatial patterns of overall GI illness at the ZIP code level reveal statistically significant clustering. The highest rates were revealed in rural areas in the coastal plain as well as portions of the Piedmont and the mountains (Figure 4). Over 20 other maps were generated at the county level to spatially analyze variables shown in Table 3.

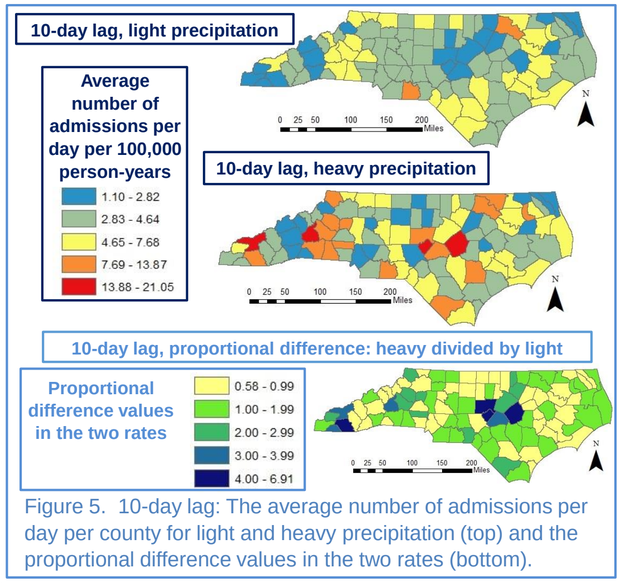
Figure 4. North Carolina ZIP code-level gastrointestinal illness ED visits per 100,000 person-years from 2008-2012.



RESULTS: PRECIPITATION

Across the state given both a 3-day lag (not shown) and a 10-day lag (Figure 5), the average number of admissions per day is higher after periods of heavy rainfall ($p<.01$). Maps of the proportional rates for both lag periods also reveal specific counties with high increases in ED visits after heavy rains (Figure 5 for 10-day lag, bottom).

Figure 5. 10-day lag: The average number of admissions per day per county for light and heavy precipitation (top) and the proportional difference values in the two rates (bottom).



CONCLUSIONS

- There are significant associations with GI illness and poverty/poverty elements in North Carolina
- There is significant clustering in proportions of disease after heavy rain at the county level
- There are otherwise unique spatial pockets of high rates of disease in NC after heavy rain

ACKNOWLEDGEMENTS

- SERCC (Southeast Regional Climate Center) & Dr. Maggie Sugg
- CISA (Carolinas Integrated Sciences and Assessments) provided support for this project
- Ashley Hiatt, North Carolina State Climate Office

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