Exploring spatial and temporal trends in U.S. childhood rotavirus hospitalization

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ABSTRACT

Introduction: Although well studied, the seasonality of childhood rotavirus infection in the U.S. is poorly understood. This research explores the spatial and temporal trends in rotavirus activity for select U.S. states and possible underlying mechanisms leading to the seasonality of rotavirus.

Methods: We compiled monthly state diarrheal hospitalizations (ages < 5) due to rotavirus (ICD-9 008.61) from the HCUP's State Inpatient Databases for 1993 -2000. We explored spatial-temporal trends in peak rotavirus hospitalizations and possible associations with relative humidity and temperature.

Results: Although peak rotavirus activity exhibited a seasonal and geographic "sweep" of activity (west to east coast) during some study years, peak activity appears to be more synchronized. Preliminary results also suggest a correlation between rotavirus hospitalization activity and temperature as well as humidity.

Conclusions: These preliminary results suggest rotavirus activity may be less predictable than previously thought.

INTRODUCTION

Rotavirus is the most common cause of acute diarrheal in children worldwide (Parashar, 1998). Clinical incidence of rotavirus peaks among children 4 to 36 months of age who are also at greatest risk for severe disease potentially requiring hospitalization. More than 50% of acute diarrhea episodes requiring hospitalization in this age group are caused by rotavirus (Barnes, 1999).

The spatial and temporal pattern of rotavirus incidence has been well studied, but remains poorly understood. Ho, et al explored national trends in diarrheal hospitalization by age, time and geographic region to assess rotavirus activity between 1979 and 1984. Hospitalizations peaked from November to April occurring primarily among children three to 35 months of age. The peak of this activity began in the Southwest U.S. in November sweeping across the country and ending in the Northeast in March and April. Jin et al repeated the analysis performed by Ho and colleagues for 1979 – 1992 concluding that the winter seasonal peaks remained constant, and the geographic pattern of these peaks (southwest to northeast) unchanged. In a five year retrospective study (1984-1988) of monthly rotavirus laboratory confirmed detections in the U.S., Canada and Mexico, LeBaron et al found regional peaks of annual rotavirus appeared to be recurrent and predictable, following a specific sequence (LeBaron, 1990). The most recent assessment of the spatial and temporal trends in rotavirus activity conducted by Torok and colleagues confirmed the previously observed geographic sequence between 1991 and 1996 utilizing laboratory confirmed specimens testing positive for rotavirus. The reason for this spatial-temporal pattern is unknown (Parashar, 1998). The goal of this research was to examine characteristics of rotavirus activity in different states and to explore the hypothesis that annual rotavirus epidemics follow a spatial-temporal pattern as defined by previous research.

METHODS

Past research has suggested that hospital discharge data is a strong predictor of rotavirus activity and has been shown to be both robust and sensitive. Monthly hospital discharge data for 1993-2000 were obtained from the Healthcare Cost and Utilization Project's (HCUP) State Inpatient Databases. Children one month to less than five years of age with an ICD-9-CM code for rotavirus (008.61) listed as one of the first three diagnostic codes on the discharge record were included in the analysis. For the study period, a total of 20,948 hospitalization records were recorded. Only states with 100% hospitalization records for all years were included in the analysis (16 states: Arizona, California, Colorado, Connecticut, Iowa, Illinois, Kansas, Maryland, Massachusetts, New York, New Jersey, Pennsylvania, Oregon, South Carolina, Washington and Wisconsin). Although a small sample, these states represent 49.3% of all children under age five in the U.S. (US Census, 2002). States included in the analysis are spread throughout the country.

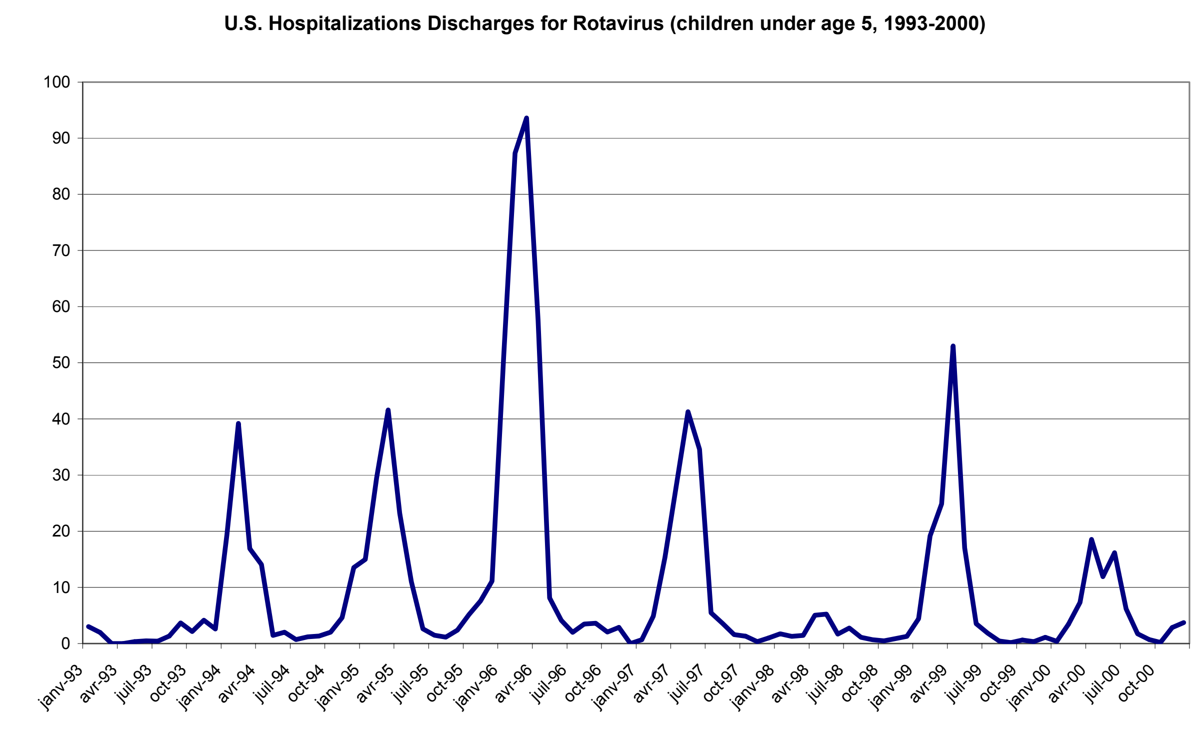
To facilitate comparison between states, we standardized hospitalizations by subtracting the mean monthly state hospitalizations and dividing by the state population under age five. Hospitalization rates (per 100,000) were calculated using census state population estimates for children under age five for 1993 – 2000 (U.S. Census, 2002). We defined the rotavirus year, as in previous research, from July through June. Peak month was defined as the month with the highest number of standardized hospitalizations. If a state exhibited a bi-modal peak, the first peak was selected as the epidemic peak.

To explore our hypothesis, we performed a series of statistical analysis to determine whether rotavirus activity moved across the country beginning in the southwest and ending in the northeast.

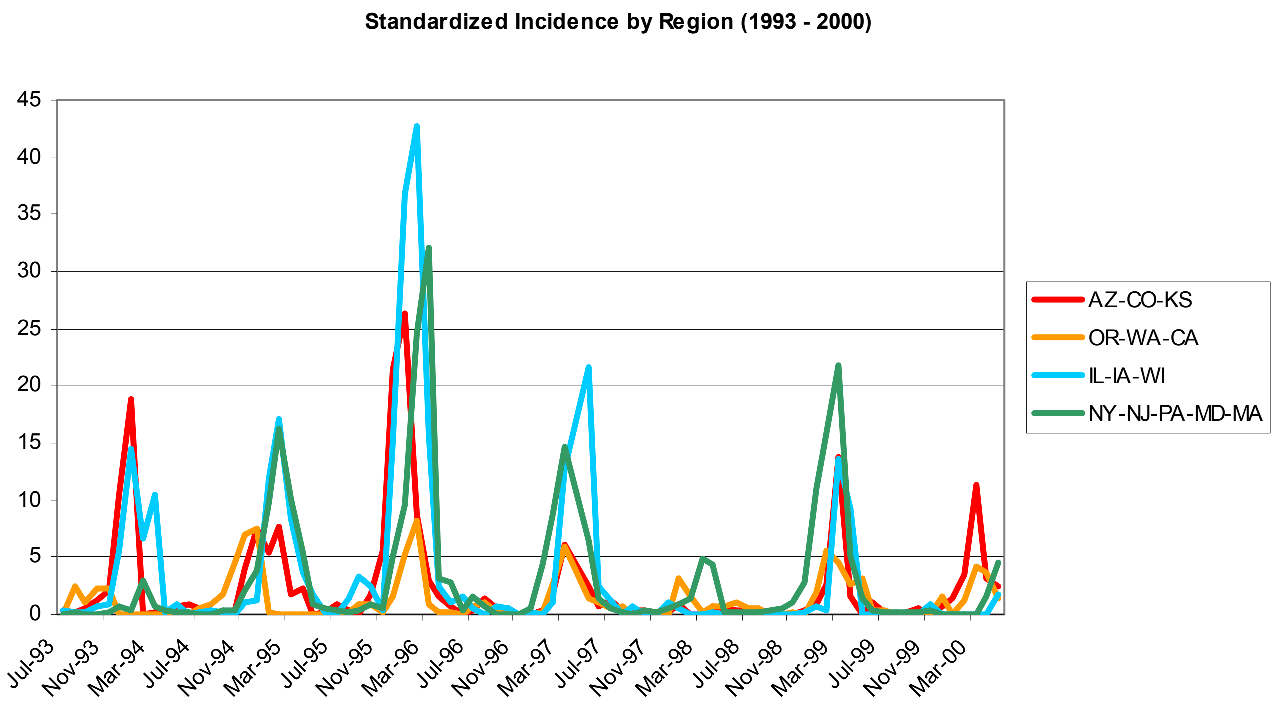
First, we divided the states into general geographic regions. Following previous analysis, we grouped states into four groups: Southwest (AZ, CO, KS), Northwest (OR, WA, CA), Midwest (IL, IA, WI) and Northeast (NY, NJ, PA, MD, CT, MA). We did not include South Carolina in the regional analysis. Because California could be considered both Southwest and Northwest, we performed the regional analysis twice with California included in either the North or Southwest. The characteristic geographic sweep was clearest when California was included in the Southwest. For the second set of analysis, we examined rotavirus activity at the state level. We chose to assume that rotavirus activity would begin in Arizona and end in the northeast. Approximate distances between Arizona's state population centroid and the other state centroids were obtained from the U.S. Census Bureau for 1996 (midpoint year in the study period). If rotavirus activity moves across the country in this manner, we would expect a linear relationship between month of peak activity and distance from Arizona. By determining the simple Pearson's correlation coefficient between peak month and distance from Arizona, we are able to assess the basic spatial-temporal correlation. Although other more sophisticated spatial temporal statistics would be appropriate as well, due to the small sample size we chose to use this straightforward assessment of correlation.

RESULTS

For the study period and all states, rotavirus peaked between February and May. Peak incidence was at it lowest for the 1999-2000 season (18.6 per 100,000) and at its greatest during the 1996-1997 season (93.6 per 100,000) with a mean of 41.9 per 100,000 (Figure 1).



When states were grouped by geographic region, the characteristics geographic sweep from Southwest to Northeast was clear for the 1994-95, 1995-96, and 1999-00 seasons (Figure 2). For the 1993-94 rotavirus season, peak activity began in the Northwest in January following to the Southwest and Midwest in February and peaking in the Northeast in March. During the 1996-97 season, peak activity occurred in the Southwest, Northwest and Northeast in March and in May for the Midwest. The following year, Midwest peak activity occurred in December, followed by the Southwest and Northwest in January and the Northeast in April 1998. For the 1998-99 season, peak activity occurred in February for the Northwest, followed by the remaining three regions in March 1999.



When peak rotavirus activity was explored at a state level, the geographic sweep was strongly exhibited for the 1993-94, 1995-96 and 1999-00 rotavirus seasons. Table 1 details the Pearson correlation coefficient between peak month and distance from Arizona. We performed the same calculations with California as the initial state. None of the study years obtained a correlation coefficient above 0.05.

Table 1: Pearson Correlation between distance from AZ and peak month	
1993-94	0.4121
1994-95	0.0017
1995-96	0.6625
1996-97	0.0059
1997-98	0.0005
1998-99	0.0053
1999-00	0.2519

DISCUSSION

These preliminary analyses suggest that the spatial and temporal patterns of rotavirus activity in the U.S. may be somewhat less predictable than previously expected. The previously observed geographic sweep is clearly evident during several of the study years, peak activity is more synchronized in others.

Although the results of this research suggest that rotavirus activity may be somewhat more synchronized than previously determined, there are several key limitations. First, because only eight years and 16 states are included in the analysis, we may not have adequate statistical power to detect the previously exhibited geographic sweep. Increasing the number of states is a clear direction for future research. Further, employing data at a more refined temporal resolution may reveal a more obvious spatial sweep.

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