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Comparison of different definitions of heat wave and their temporal association with hospitalization related to infectious gastroenteritis among US elderly, 1991-2004

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Background

Elderly is susceptible to infectious gastrointestinal (GI) diseases and excessive heat events. GI pathogens (e.g. *Salmonella*) grow favorably in warmer weather which may further magnify the risk. Increased GI rates after temperature peaks are documented. Currently, multiple definitions of heat waves are used, and their individual association with GI in elderly are not well studied.

Methods

We applied two different definitions of heat wave and compared their predictive capability of upcoming GI-related hospitalizations. Daily hospitalization data from the Centers of Medicare and Medicaid Services (CMS) and commercially available daily climate data from 1991 through 2004 were abstracted for this analysis. Heat waves are defined as (i) absolute: daily maximum temperature $>90^{\circ}\text{F}$ for three consecutive days, and (ii) relative: daily maximum temperature >1.6 standard deviation compared to the 365-day moving average.

Results

Preliminary analysis using data from Illinois identified 35 absolute heat waves and 54 relative heat waves, with 24 days commonly classified by the both methods. Time series analysis showed that GI-related hospitalizations (ICD 9-CM 001–009, excluding *C. difficile*) and daily maximum temperature peak at about the same time ($209^{\text{th}} \pm 7.2$ vs. $210^{\text{th}} \pm 0.6$ calendar day). First heat waves appear earlier (191^{st} for absolute heat wave and 180^{th} for relative) than the peak of hospitalization. A more geographically extensive analysis covering the 122 cities used by the CDC Mortality Reporting System will be performed.

Conclusion

Establishment of a warning system of upcoming heat waves may help preparing the elderly against potential GI infections and heat-related illness.

Hospitalization for *Clostridium Difficile* in the US Elderly: Co-morbidity and Seasonal Drivers

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Background

In the US, over 300,000 cases of *Clostridium difficile* associated diarrhea occur annually in hospitals or long-term care facilities and incidence has risen over the past two decades.

Though *C. difficile* is considered to be a hospital acquired disease, we have demonstrated a clear seasonal pattern which may indicate a strong environmental influence. *C. difficile* seasonality can also be driven by co-morbid conditions or infections with well defined seasonal patterns.

Methods

All 1,054,125 hospitalization records for the US elderly with *C. difficile* were abstracted from the Centers for Medicare and Medicaid Services (CMS) database for a 14-year period (1991-2004). The most common co-morbid conditions, identified using the Elixhauser categorization scheme, were fluid and electrolyte disorders (429,152 cases, 40.7%) and hypertension (349,522 cases, 33.2%). Seasonality was assessed for the subset of cases with electrolyte disorders and hypertension, both of the co-morbid peaks were closely aligned to the peak for *C. difficile*. Several *C. difficile* cases also reported gastrointestinal symptoms (ICD 787,558.9) (62,687 cases, 5.95%) and ill-defined intestinal infections (ICD 008.5,008.8,009) (2358 cases, 0.2%). We tested whether these gastrointestinal conditions may drive seasonality of *C. difficile*.

Results

All hospitalization records for gastrointestinal symptoms and ill-defined intestinal infections were extracted from the complete hospitalization dataset and seasonality was assessed. The peak for both gastrointestinal symptoms and ill-defined intestinal infections precedes the peak in *C. difficile* (31st and 30th, respectively vs. 34th calendar week).

Conclusion

These results suggest that the seasonal pattern seen in *C. difficile* may be driven by hospitalization for other intestinal infections.

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Estimating Number of Elderly Affected by Atlantic Storms in 1998-2002 using Geographical Information System

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Background

Natural disasters pose a serious threat to welfare of vulnerable populations. Due to infrastructure disruption and population displacement that typically occur as the consequences of extreme weather events, the assessment of health effects is difficult. Often even simple estimates of affected population are not readily available to public health professionals. In this study, we develop methodology for estimating the number of elderly affected by Atlantic storms in 1998-2002 using Geographical Information System (GIS).

Methods

Information on 25 storms was abstracted from the U.S. National Oceanic & Atmospheric Administration including date, time, and epicenter coordinates in a six-hour interval. To reflect degree of exposure the storm tracks were mapped with three buffers: 50, 75, and 100 miles from storm trajectory. Number of elderly older than 65 affected by storms were estimated by overlaying the storm buffer areas with county maps linked to Census 2000 demographic data. Counties with centroid inside in the buffer area were considered affected.

Result

Of 25 Atlantic storms made landfall between 1998 and 2002, 5 were category 4 or higher, 6 were category 2 and 3. In the 31 states from South Atlantic, Middle Atlantic, New England, East North Central, and West South Central divisions, the recorded storms have accumulatively affected 3,531 counties with 390.3 million people out of whom 49.7 million (12.7%) were elderly. Proportion of elderly affected to total population varies storm by storm, from 0.2% to 33.4%.

Conclusion

The obtained estimates provide important insights on the magnitude of exposure to extreme weather events among the US elderly.

Trends and Seasonal Patterns in Hospitalization Rates of Clostridium Difficile in the US Elderly

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Background

In the US, over 300,000 cases of *Clostridium difficile* associated diarrhea occur annually in hospitals or long-term care facilities and incidence has risen over the past two decades due to increased antibiotic use. It is plausible that *C. difficile* hospitalizations exhibit temporal patterns similar to seasonality of dominant pathogens for which antibiotics are prescribed. We hypothesize that the presence of pathogens and their pathogenicity are driven by environmental factors and therefore demonstrate seasonal patterns.

Methods

All 448,914 hospitalization records for the US elderly for *C. difficile* were abstracted from the Centers for Medicare and Medicaid Services (CMS) MedPAR database for a 5-year period (1998-2002). Hospitalization rates due to *C. difficile* were increasing: 21.6, 22.8, 23.4, 26.6, and 32.3 per 10,000 elderly per year ($p < 0.05$). Of all cases 10,256 (2.3%) exhibited co-morbid antibiotic resistance. The overall number of antibiotic co-morbid cases increased and the percentage of antibiotic co-morbid cases demonstrated an increasing trend ($p < 0.05$) from 1.9% to 2.5% over the 5-year period.

Results

As expected, the highest rate of hospitalizations was observed in the 85+ years old individuals (76.5 per million population vs. 18.7 in 65-74 y.o., and 17.7 in 75-84 y.o.). Counts were organized into weekly time series and the highest rates of *C. difficile* were observed in mid-March (week 11 ± 0.23) for all age groups.

Conclusion

These results suggest that *C. difficile* is associated with environmental characteristics and demonstrates clear seasonal patterns. Further analysis will explore seasonality in two cohorts, with and without antibiotic resistance.

The Use of Köppen Climate Classification System for Public Health Research

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Background

Significant evidence suggests that rates and seasonal patterns in infectious diseases are related to precipitation, ambient temperature, and climate. Climate classification can be useful in characterizing rates of infectious diseases. The Köppen climate classification system is the most widely used and understood classification. This classification was developed for climatology and has not been utilized for public health research. We suggest an adaptation of the Köppen climate classification and demonstrate its utility by describing the incidence of campylobacteriosis, a disease caused by thermo-sensitive bacteria in which diverse seasonal patterns have been observed worldwide.

Methods

We methodically evaluated the Köppen climate classification system which is based on monthly temperature and precipitation and developed an algorithm to adapt it for US county level analysis. Each county was classified based on meteorological norms and using data specific to each year of study (1998-2002). Classifying each year individually allows for comparison between the years and also to assess temperature and precipitation variability in each county. We developed stability and diversity indices to quantify this variability. We abstracted data on campylobacteriosis from the Centers for Medicare and Medicaid Services (CMS) dataset for each county for the 5-year period.

Results

The adapted climate classification system utilizes 9 climate zones compared to the 18 in the original climate classification for the US. We were able to determine that the highest rate (2.21 ± 3.4 cases per 10,000 elderly) of campylobacteriosis was seen in the northern counties of Minnesota and South Dakota. High rates were also seen in the colder climates of the upper Midwest and the Northern Plains. The lowest rate of campylobacteriosis (0.43 ± 0.69 cases per 10,000 elderly) was seen in the dry arid regions in the southwestern US.

Conclusion

These preliminary results indicate campylobacteriosis sensitivity to climate and call for more detailed study.

Temporal variations in *Salmonella* infections among the US elderly, 1991-2002

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Background

Salmonella contaminations of raw meat and poultry have dropped substantially since the introduction of the Pathogen Reduction/Hazard Analysis and Critical Control Points (PR/HACCP) in 1998, according to the US Department of Agriculture. In populations with compromised immunity, such as elderly, infection may be followed by enteric fever, septicemia, and worsening chronic illnesses. Exposure to *Salmonella* may vary by season. Better understanding of the trend and seasonality will enable more efficient prevention strategies. Using national hospitalization records from the Centers for Medicare and Medicaid Service, we examined temporal changes in salmonellosis among US elderly residents (65+ yo).

Methods

We abstracted 24,172 records of hospitalization due to *Salmonella spp.* (ICD9CM 003) in the continental part of the US in 1991-2002. For each of the four regions: Northeast, Midwest, South, and West, we created a set of time series of weekly counts. Poisson harmonic regression models were used to determine trend and seasonal curve attributes: relative intensity (ratio of max and min) and peak timing. Data analysis and visualization were conducted using SPSS, SAS, and ArcGIS9.1.

Results

The rate of hospitalization due to *Salmonella spp.* has declined: annual rate dropped from 59.7 in 1998 to 52.2 cases per million elderly in 2002 ($p < 0.001$). Seasonality of salmonellosis differs between US regions. The South region exhibits the highest weekly average rate (0.03/million elderly vs. 0.02, 0.02, 0.01), the highest relative intensity (2.8 vs. 2.2, 2.2, 1.7) compared to Northeast, Midwest, and West respectively. Northeast has the longest timing to peak (34th week vs. 33rd week in others; $p < 0.05$).

Conclusions

The observed trend suggests possible impact of the PR/HACCP on the incidence of *Salmonella* infections among the elderly. The effects of season-sensitive environmental factors and relevant social and behavioral parameters on the revealed oscillations in *Salmonella* hospitalizations should be examined in details.

The Use of Remote Sensing to Assess Global Trends in Seasonality of Cryptosporidiosis

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Introduction

Cryptosporidiosis is a diarrheal illness caused by protozoan, which is spread through water contaminated with human or animal feces. Cryptosporidiosis typically manifests through a low endemic level and well-pronounced seasonal outbreaks, indicating strong effect of environmental factors. Though cryptosporidiosis is self-limiting in immuno-competent people, it can be life threatening to immuno-compromised individuals, such as those with AIDS and the malnourished. Studies conducted in various locations have noted an increase in cryptosporidiosis during the warm and rainy season. We conducted a meta-analysis to examine how an increase in cryptosporidiosis relates to precipitation and ambient temperature worldwide. We also investigated the potential of using remote sensing data as a proxy for exposure to cryptosporidiosis globally.

Methods

We abstracted data on monthly incidence of cryptosporidiosis from 40 published epidemiological studies conducted worldwide, including Guinea Bissau, Gambia, Brazil, Costa Rica, Germany, Switzerland, and India. The selected studies cover tropical and temperate climates worldwide and were classified using the Köppen Climate Classification. Based on the study's location, we supplemented monthly incidence data with aggregated norms for ambient temperature and precipitation, obtained from the National Climatic Data Center databases. We also used Normalized Difference Vegetation Index (NDVI) data, which is a measure of the density of plant growth from satellite images, as a proxy for precipitation and exposure to the pathogen via contaminated water. The incidence data and meteorological data were normalized into z-scores on an annual basis for each location. We applied a linear mixed effects model to link the z-score of cryptosporidiosis incidence with ambient temperature, precipitation, and NDVI.

Results

Analysis was performed to include all study sites. We modeled precipitation and NDVI as an independent effect and adjusted for temperature and their interaction. Overall precipitation is a strong predictor for NDVI in all climate categories and temperature is a positive predictor of NDVI in the humid middle latitude category. In the humid middle latitude climate zones, a half unit change in NDVI (from the minimum, ~ 0.25 , to the maximum, ~ 0.75 , density of plant growth) is associated with a change of 2 to 4 units in the z-score of monthly crypto incidence. Our results demonstrate a strong positive relationship between precipitation or NDVI and disease incidence as measured by z-score. When considering both precipitation and ambient temperature, temperature was also a significant predictor, exhibiting an independent effect on the incidence of cryptosporidiosis.

Conclusion

Our results provide a quantitative link between the incidence of cryptosporidiosis and meteorological parameters, precipitation or NDVI and temperature. Overall in warm and wet locations precipitation is a strong predictor for incidence of cryptosporidiosis. In temperate climates cryptosporidiosis incidence is better predicted by temperature and NDVI. The observed strong associations between cryptosporidiosis incidence and precipitation may suggest that while climatic conditions typically define a habitat area of a pathogen, meteorological factors can affect timing and intensity of infectious outbreaks, leading to different seasonal patterns in various climates of the world. The proposed methodology can be applied to a variety of water-borne diseases and infections caused by thermo-sensitive pathogens.