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Variation in pediatric gastroenteritis admissions among Florida counties, 1995-2002

Jean Lee
University of South Florida

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Variation in Pediatric Gastroenteritis Admissions Among Florida Counties, 1995-2002

by

Jean Lee

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctorate of Philosophy
College of Nursing
University of South Florida

Major Professor: Mary Evans, PhD
Jason Beckstead, PhD
Etienne Pracht, PhD
Roger Boothroyd, PhD

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Dedication

This work is dedicated to my husband and son. They were a source of unfailing support and understanding throughout my program.

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I would like to acknowledge the support provided by Dr. Mary Evans and Dr. Cecile Lengacher. I am deeply grateful for the guidance they provided throughout the program.

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Variation in Pediatric Gastroenteritis Admissions
Rates Among Florida Counties, 1995-2002

Jean Lee

ABSTRACT

Background: Hospitalizations for pediatric gastroenteritis are considered potentially avoidable and are used to monitor access and quality of primary care for children. Previous reports have found pediatric gastroenteritis admissions higher in Florida compared to the South and the nation.

Purpose: The purpose of this project was to explore variation in county admission rates for pediatric gastroenteritis related to non-clinical factors in Florida during 1995-2002. Specific aims included identifying the unique contributions of county socioeconomic characteristics and availability of primary care resources to annual county pediatric gastroenteritis hospital admission rates.

Method: The study was retrospective and longitudinal assessing variation in annual county admission rates for pediatric gastroenteritis from 1995 to 2002. Secondary data sources included Florida hospital discharge data and multiple publicly available state and federal datasets. Explanatory variables included county-level measures of socioeconomic status and primary healthcare resources.

Analysis: Multivariate analysis was performed using multilevel modeling techniques. A two-level, random coefficients model was constructed in HLM6 to account for variation over years and across counties. Linear and non-linear trends over time were also assessed.

Results: None of the hypotheses were supported by the data. The average pediatric gastroenteritis admission rate across all occasions and counties was 205.72 admissions per 100,000 child population. The proportion of children 0-4 years was the only significant predictor of pediatric gastroenteritis rates.

Conclusion/Discussion: The significant effect of age on admission rate was not surprising and was well supported in the literature. Missing data issues and low statistical power may have contributed to the lack of significant effects of other explanatory variables.

Chapter One: Background and Significance

Introduction

The elimination of health disparities is a national priority in the United States (Office of Disease Prevention and Health Promotion, n.d.). The National Institutes of Health (NIH) define health disparities as “differences in the incidence, prevalence, mortality and burden of diseases and other adverse health conditions that exist among specific population groups in the United States” (NIH, n.d). The Institute of Medicine defined disparities more specifically as “racial and ethnic inequity found in the quality of healthcare that are not due to access-related factors or clinical needs, preferences and appropriateness of intervention” (p.32) (Smedley, et al. 2003).

The pervasiveness of health disparities in the United States reveals longstanding inequity for socially disadvantaged groups such as racial/ethnic minorities and the poor or near poor (Kawachi, Daniels, & Robinson, 2005; Putsch & Pololi, 2004). Health disparities exist despite highly trained providers and some of the most advanced facilities, treatments and technology available in the world. Since 2003, the Agency for Healthcare Research and Quality (AHRQ) has sponsored the annual *National Healthcare Disparities Reports* (NHDR) which reported that health disparities exist in all sites of care, for all conditions and at all points in the process (AHRQ NHDR, 2003; 2004; 2005).

The overall goal of this project is to increase the understanding of health disparities in potentially avoidable hospitalizations due to acute gastroenteritis in

children. In addition to a discussion of health disparities, primary care and potentially avoidable hospitalizations, chapter one contains the problem statement, conceptual framework and hypotheses of this project.

Health Disparities in Children

Disparities in health and health care are not limited to adults. Disparities in children may be even more pronounced because of exposure to multiple risk factors and numerous vulnerabilities. First, children are more likely to live in poverty and be from racial/ethnic minority groups than adults (Beal, et al., 2004). In addition, minority children are more likely to be uninsured or have public coverage and have parents with limited-English proficiency and lower educational attainment (Beal, et al., 2004; Flores, Olson, & Korman, 2005; Leatherman & McCarthy, 2004).

Primary Care

Primary health care is an essential component for the health and well being of children. Primary care services are designed to optimize personal health and well being through health promotion, illness prevention, health maintenance, counseling, education, diagnosis and treatment of acute and chronic illnesses (American Academy of Family Physicians, 2005; American Academy of Pediatrics [AAP], 1999). Pediatric primary care involves monitoring physical and psychosocial growth and development, health supervision, age appropriate screening, management of acute and chronic disorders, appropriate referrals to specialists, anticipatory guidance and coordinated management of health problems requiring multiple professional services (AAP, 2003).

In primary care, minority children are more likely to receive poor quality care in terms of provider interactions, preventive services and management of common conditions. Parents of minority children reported lower quality of interactions and satisfaction with

providers (Flores, Olson, & Korman, 2005; Simpson, Owens, Zodet, Chevarley, Dougherty, & Elixhauser, 2005). Disparities related to preventive recommendations have been found in well-child visits, immunizations, lead screening, sexually transmitted disease screening and dental care (Leatherman & McCarthy, 2004).

Potentially Avoidable Hospitalizations

Ambulatory care-sensitive conditions (ACSC) consist of acute and chronic conditions for which appropriate and timely primary or preventive care exists and can prevent or reduce the need for hospitalization. In 2000, it was reported that nearly five million people were hospitalized for ACSCs with an estimated cost of \$26.5 billion (Kruzikas, Jiang, Remus, Barrett, Coffey, & Andrews, 2000).

Monitoring potentially avoidable hospitalizations for ACSCs provides an index to gauge the quality of primary care in a community and compare the quality of primary care across communities (AHRQ Guide to Prevention Quality Indicators, 2005; Millman, 1993). ACSC admission rates can also identify groups with large unmet health needs. Examples of ACSCs studied in children include asthma, short-term complications of diabetes, bacterial pneumonia, seizure disorder, urinary tract infections, cellulitis, dehydration, perforated appendix and acute gastroenteritis (Kruzikas et al., 2000).

It is important to understand that the phrase *avoidable hospitalization* does not imply that all ACSCs are preventable or that the hospitalization is avoidable at the time of admission. Clinical or social factors such as severe preexisting disease, very young age, an overwhelmed family and long travel distances to a provider or facility may necessitate admission (Soulen, Duggan, & DeAngelis, 1994). The phrase *potentially avoidable hospitalization* is used to reflect this distinction.

Pediatric Gastroenteritis

Acute gastroenteritis is a common childhood condition most often due to viral agents and is self-limiting in nature. Symptoms are generally mild and include vomiting and diarrhea. Oral rehydration, the recommended treatment for gastroenteritis, is simple, inexpensive and can be effectively performed in the home or outpatient setting. Lack of or inappropriate treatment can lead to hospitalization for treatment of serious and potentially fatal complications secondary to fluid and electrolyte losses (AAP, 1996; Burkhart, 1999; Centers for Disease Control and Prevention [CDC], 2003; Eliason & Lewen, 1998).

In the United States, pediatric gastroenteritis was reportedly responsible for 320,000 pediatric hospitalizations and 3.7 million physician visits annually in children under age five (AHRQ National Healthcare Quality Report [NHQR], 2003). Treatment for rotavirus, an agent responsible for one third of diarrhea-related hospitalizations in children under age five, had an estimated annual direct medical cost of \$250 million and societal cost of \$1 billion (CDC, 2003).

The national admission rate for pediatric gastroenteritis decreased from 2001 to 2002 (106.3 to 92.0 per 100,000 child population respectively), however, the decrease was found primarily in white children. Pediatric gastroenteritis admission rates for minority children essentially did not change during that same time period (AHRQ NHQR, 2005).

Problem Statement

The pediatric gastroenteritis rate was recommended as a prevention quality indicator by AHRQ, however, currently there is no clear benchmark for an acceptable or preferred admission rate (AHRQ, Pediatric Gastroenteritis Admission Rate, 2004). After adjusting for age and gender, Florida's pediatric gastroenteritis admission rate in 2001 was higher than the nation and the southern region (121.4 vs. 106.3 and 111.4 per 100,000 child population

respectively). Of the 32 states listed, Florida had the eighth highest rate (AHRQ Table 1.66a-b, 2004). No evidence was found addressing factors that were associated with disparities in gastroenteritis admissions in Florida's children.

To better understand which factors contributed to disparities in pediatric gastroenteritis admissions in Florida, it was necessary to assess admission rates across counties. The purpose of this project was to explore variation in annual county admission rates for pediatric gastroenteritis in Florida related to non-clinical factors during 1995-2002. The specific aims of this study were to identify the unique contribution of county-level socioeconomic status factors and primary healthcare resources to county pediatric gastroenteritis admission rates during this period.

Conceptual Framework

The Vulnerable Populations Conceptual Model (Figure 1) served as the conceptual framework of this project (Flaskerud and Winslow, 1998). The model was designed for research, practice and analysis at the community or population level. A cyclic relationship was postulated among resource availability, relative risk and health status. Resource availability referred to the availability of societal as well as environmental resources. In the model, decreased availability of societal (i.e., human capital, social connectedness and social status) and environmental (i.e., access to and quality of health care) resources was associated with increased relative risk and decreased health status (i.e., increased morbidity and mortality). Decreased health status leads to further decreases in resource availability and increases in relative risk.

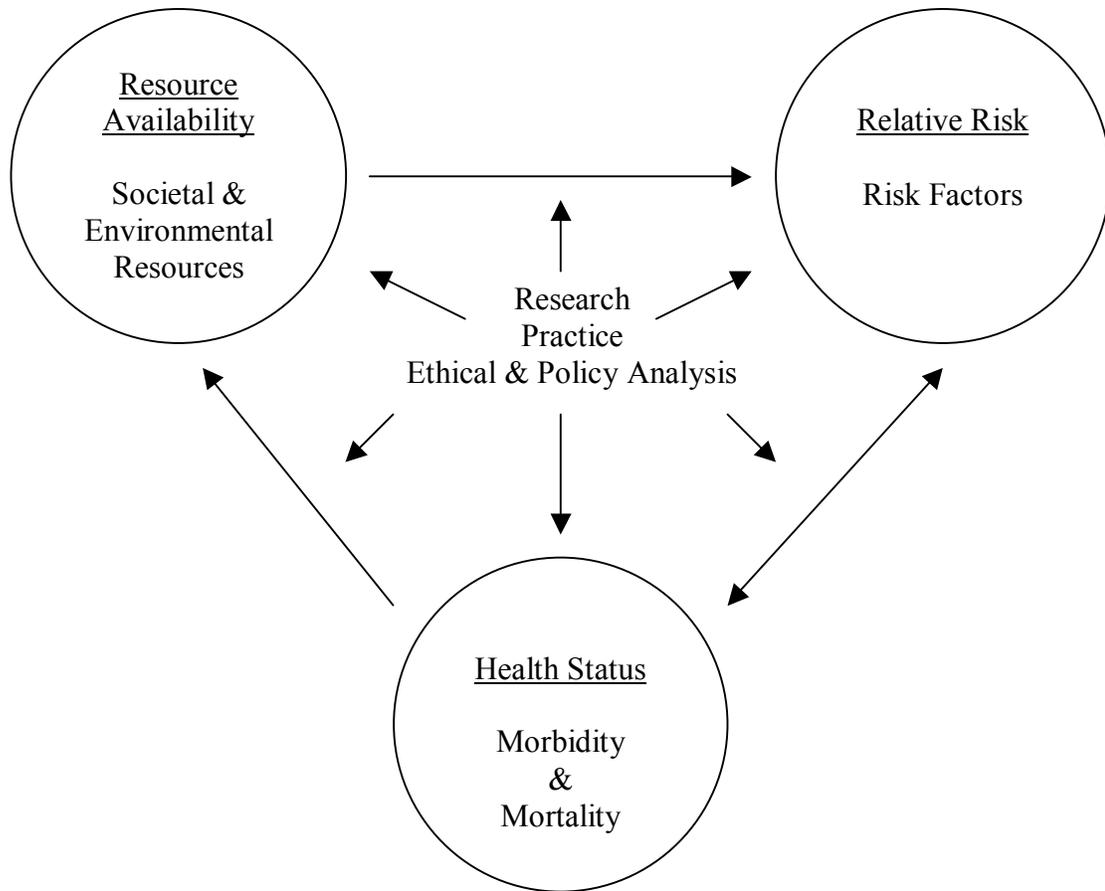


Figure 1. Flaskerud and Winslow’s Vulnerable Populations Conceptual Model

The focus of this project was the indirect relationship from resource availability to health status. A county’s pediatric gastroenteritis admission rate, an indicator of the health status of its child residents, was associated with the relative amounts of resources available within the county. Relative risk and its associated relationships postulated in the model were not evaluated in this project.

Socioeconomic Status

Societal resources of interest were related to socioeconomic status. For the purposes of this project, socioeconomic factors under evaluation included the county median

household income and proportions of the county child population from racial/ethnic minorities and living in poverty. Residents in counties with lower incomes or higher rates of the child population from racial/ethnic minorities or living poverty would have lower social status, fewer societal resources and increased admission rates compared to counties with higher incomes or fewer minority or poor children.

Pediatric Primary Health Care Resources

Environmental resources of interest were related to the pediatric primary health care system. For the purposes of this project, pediatric primary care factors under evaluation at the county level included the number of community hospitals, federally funded clinics, child-serving primary care physicians, rural-urban level and degree of managed care penetration (i.e., the proportion of the population in managed care health plans).

Lack of primary care facilities (e.g., clinic and physician supply) and increased acute care facilities (e.g., community hospital supply) were hypothesized to lead to increased admissions. Increased managed care penetration, with its emphasis on primary care and prevention, was hypothesized to lead to decreased admissions. The direction of the association between rural-urban level and admission rate was not specified because rural areas tend to have fewer of all health care resources, primary and acute care, whereas urban areas tend to have more.

Hypotheses

The hypotheses related county level characteristics and county pediatric gastroenteritis admission rates. The hypotheses of this project were

H_1 : The proportion of the child population from racial/ethnic minority groups is positively associated with county admission rate.

H_2 : The proportion of the child population living in poverty is positively associated with county admission rate.

H_3 : County median household income is negatively associated with county admission rate.

H_4 : County rural-urban level is associated with county admission rate.

H_5 : County, pediatric-serving, primary care physician supply is negatively associated with county admission rate.

H_6 : County, federally-funded clinic supply is negatively associated with county admission rate.

H_7 : County hospital supply is positively associated with county admission rate.

H_8 : County managed care penetration is negatively associated with county admission rate.

Significance to Nursing

This project contributed to the profession of nursing by expanding its involvement in health services research for vulnerable populations and exposing the complexity surrounding health disparities in Florida children. Health services research focuses on understanding the health needs and outcomes for specific groups at the community or population level.

Although nursing is traditionally thought of as being concerned with the health needs of individuals, it is also concerned with the needs of the community. Findings from this project contributed to scientific knowledge in nursing by identifying patterns of disparities and risk factors associated with increased pediatric gastroenteritis admissions.

Findings of this study contributed to clinical knowledge in nursing by identifying areas in need of continuing education for nurses. Nurses in outpatient settings can improve the quality of care for children with acute gastroenteritis through accurate assessments and

support for children and caregivers. An awareness of socioeconomic factors associated with avoidable hospitalizations can help identify those children and families at increased risk for an avoidable hospitalization. Every child with acute gastroenteritis has unique considerations, but knowledgeable and supportive nurses can help children receive effective treatment in the appropriate setting.

Chapter Two: Review of the Literature

Introduction

Research focused on variation in admission rates related to non-clinical factors has been retrospective. Many suggested non-clinical factors reflect long-standing social inequity for specific populations. The majority of what is known about these relationships has come from research in which pediatric gastroenteritis was examined grouped with other pediatric or adult ACSCs. Chapter two contains a review of the scientific evidence concerning the relationship between ACSC admissions in children and their socioeconomic status and the primary care services available to them. A search of the scientific literature was performed dating back to 1997.

Although many of the findings overlap, this review is organized into sections related to the primary focus of the research. Sections include variations in pediatric gastroenteritis focused on socioeconomic status, primary care services and managed care. The studies in each section are in chronological order to follow how our understanding of the relationship between each area and admissions has progressed. Many patterns in the findings are consistent across studies; however, some are not.

Socioeconomic Status

Socioeconomic status was associated with disparity in many aspects of health care. Socioeconomic status was associated with ACSC admissions in children at the national level (AHRQ NHDR, 2005; Kruzikas et al., 2000). Socioeconomic status was of

interest because of its relationship with access and utilization of health care services.

Socioeconomic status factors associated with variation in pediatric gastroenteritis admissions included income, insurance, race/ethnicity and location of residence.

McConnochie, Roghmann and Liptak (1997) performed a retrospective analysis of county data to examine the relationships among geographic area and mandatory and discretionary admission rates in young children. The sample included children, less than two years old, discharged from one county in New York State during 1985-1991. Geographic areas were classified by zip codes into inner-city, other urban and suburb areas. Admission rates were calculated per 1,000 child-years. Gastroenteritis/dehydration was one of eleven conditions included under discretionary hospitalizations.

Discretionary admissions accounted for 59.1% of all admissions with asthma and gastroenteritis as the two most common causes. Inner city children had the highest rates of both discretionary and mandatory admissions. The discretionary admission rate for inner city, other urban and suburban children was 55.2, 30.6 and 19.9 per 1,000 child-years respectively. Discretionary admissions accounted for almost 79% of the difference between inner-city and suburban overall hospitalization rates (82.9 versus 38.1 per 1,000 child years respectively).

Multivariate analysis revealed inner city children had increased odds of a discretionary admission (odds ratio [OR]=2.28, $p<.00$) compared to suburban children after controlling for the number of births, insurance, prenatal care, housing, low birth weight, children in poverty, income, unemployment and maternal characteristics in each geographic area. Maternal education was the only significant predictor ($\beta=.95$, $p<.00$) of discretionary admissions explaining 89% of the variation. Race/ethnicity and payer status may have accounted for some of the differences attributed to different geographical locations because

larger proportions of inner-city children were black and covered by Medicaid (61.8% and 65.0% respectively) compared to suburban children (2.6% and 5.7% respectively).

Shi, Samuels, Pease, Bailey and Corley, (1999) performed a retrospective analysis of state discharge data to assess the relationships between child characteristics and ACSCs admission rates. Cost implications were also assessed. Children and adults were studied separately. The child sample included children, less than eighteen years old, discharged from short-stay hospitals in South Carolina during 1995. Gastroenteritis was one of nineteen child ACSCs included. Admission rates were calculated per 10,000 child population.

Excluding births, ACSCs accounted for 34% of child discharges. Multivariate analysis found significantly increased odds of an ACSC admission for children who were aged 0-5 years, male, non-white, low-income, rural, uninsured and with no primary care physician ($p < .05$). Gastroenteritis was the fourth most common ACSC encountered after bacterial pneumonia, asthma and dehydration. The charges for ACSC admissions in children totaled \$44 million or 20% of charges for all discharges of children.

Djodjonegoro, Williams, Aday and Ford (2000) performed a retrospective analysis of county discharge data to assess the relationship between area income and avoidable hospitalizations in low-income populations who used the public hospital system. The sample included children and adults, less than 65 years old, discharged from public hospitals in one county in Texas during 1995. ACSCs were categorized as preventable, acute or chronic. Gastroenteritis was included as one of eight acute ACSCs. Marker conditions (appendicitis with appendectomy and fracture of the neck or femur), which are considered unavoidable and should show no variation by income, were used for comparison. Admission rates were calculated per 1,000 eligible population. Low-income zip codes were defined as those having

40% or more households with incomes below \$15,000. High income zip codes were defined as those having 10% or fewer households with incomes below \$15,000.

Although most zip codes fell into the middle-income group, most of the individuals seen in the public hospitals came from low-income areas. Black males had the highest admission rates for each the top five most common ACSCs. Black females had the second highest admission rates for three of the top five ACSCs. Hispanic males also had relatively higher ACSC admission rates compared to whites. Multivariate analysis found the percentage of households with incomes less than \$15,000 explained about 69% of the variance in ACSC admissions ($R^2=.69$, $p<.00$) compared to 38% for marker conditions ($R^2=.38$, $p<.00$) after controlling for income differences within areas.

Gaskin and Hoffman (2000) performed a retrospective analysis of discharge data from ten states to assess racial and ethnic differences in avoidable hospitalizations with a focus on Hispanics. The child sample included discharges, less than eighteen years old from Arizona, California, Florida, Massachusetts, Missouri, New Jersey, New York, Pennsylvania, South Carolina and Virginia during 1996. Obstetrical, mental health and newborn discharges were excluded. Gastroenteritis was one of 20 ACSCs included. Health care needs and severity of illness were controlled using comorbidities.

Multivariate analysis found Hispanics, of all payer types (i.e., private, Medicaid and uninsured) were more likely to have an ACSC admission in five out of the ten states compared to whites. Three of the five states with an increased likelihood of an ACSC admission have large Hispanic populations (California, Florida and New York). In California and Florida, black children with private insurance and Medicaid, were significantly more likely to have an ACSC admission compared to whites. The opposite was true for black children in South Carolina and Virginia.

Kaestner, Racine and Joyce (2000) performed a retrospective analysis of national discharge data to assess the affect of Medicaid expansions on trends in discretionary and mandatory admission rates by income. The sample included children, less than two years old, discharged during two one-year periods (1988 and 1992). These periods were chosen to capture the state of discretionary and mandatory admissions before and after expansions in Medicaid. The authors hypothesized that Medicaid expansions should improve access to primary care for poor children and result in lowered rates of discretionary admissions for poor children compared to non-poor children in the later time period.

Discretionary and mandatory admission rates were calculated as ratios of discretionary and mandatory admissions to births. The sample included discharges from 326 hospitals in eight states (California, Colorado, Florida, Iowa, Illinois, Massachusetts, New Jersey and Washington) stratified by median income of residence. Children were categorized as residing in poor (<\$25,000), near-poor (\$25,000-\$30,000) and high-income (>\$30,000) areas. Gastroenteritis/dehydration was one of eleven conditions included under discretionary admissions.

Lower respiratory conditions, acute fever and gastroenteritis were responsible for 93% of all discretionary admissions. Compared to 1988, the discretionary admission rates were higher in 1992 for children from both poor and high-income areas. The increase was higher for children from poor areas, but not significantly higher compared to the increase found in children from high-income areas. For all conditions, children from poor areas had a discretionary admission rate 3.1% higher and a mandatory admission rate that was 0.2% higher compared to children from high income areas. They concluded that Medicaid expansions did not decrease in the gradient in the discretionary admission rate between children from poor and high-income areas. The discretionary admission rate for

gastroenteritis was 0.9% points higher for children from poor areas compared to children from high-income areas ($p < .01$).

Parker and Schoendorf (2000) performed a retrospective analysis of national discharge data to assess the relationship between child characteristics and ACSCs admissions. The sample included children, 1-14 years old, discharged during 1990-1995. Gastroenteritis was one of six conditions included. ACSC admission rates were calculated per 1,000 child population.

The overall ACSC admission rate was 10.9 per 1,000 child population. Multivariate analysis found younger, black, Northeastern, Medicaid and low-income children had significantly higher ACSC admission rates. Children aged 1-4 years had an ACSC admission rate more than three times greater than children aged 5-14 years (21.6 versus 6.4 per 1,000 child population). Black children overall and at every income level had higher rates than white children. In every subgroup of age, race, region and insurance status, the highest ACSC admission rates were consistently found in children from the poorest areas. Overall, the trend of ACSC admission rates by income was significant with rates increasing as income decreased. This trend was significant in every subgroup except for blacks, uninsured and Medicaid enrolled children.

The gastroenteritis admission rate was 22.7 per 1,000 child population. The profile of gastroenteritis admissions alone differed from the collective profile of all ACSCs admissions. Higher admission rates for gastroenteritis were found in children who were, younger, privately insured, white, residing in wealthier areas and living in the South. The most striking difference in gastroenteritis admission rates was between racial subgroups with the rate for whites more than twice that of blacks (26.1 versus 12.4 per 1,000 child population).

Shi and Lu (2000) performed a retrospective analysis of national survey data to examine the relationship between individual socioeconomic characteristics and child ACSC admissions while controlling for hospital characteristics. The sample included children, 0-15 years old, discharged from a short-stay hospital during 1994. Newborns were excluded. Gastroenteritis was one of 20 ACSCs included. Admission rates were calculated per 1,000 child population.

ACSCs accounted for 29.1% of eligible admissions. Gastroenteritis was the third most common ACSC following asthma and bacterial pneumonia and accounted for 11.3% of ACSC admissions. Multivariate analysis found that younger children, blacks and Medicaid beneficiaries had significantly higher odds of an ACSC admission ($p < .05$). Hospital size and ownership were also significantly associated with ACSC admissions.

Cable (2002) performed a retrospective analysis of county data to assess the effects of per capita personal income, race and ethnicity on variation in preventable hospitalizations during 1993-1995. The sample included children and adults, 1-64 years old, residing in two counties in New Jersey. Gastroenteritis was one of 28 ACSCs included. ACSC admission rates were calculated per 10,000 population.

ACSC admission rates ranged from 4.3 to 75.7 per 10,000 population. Multivariate analysis revealed lower income ($< \$25,000$) and higher percentages of nonwhite race were strongly associated with high preventable hospitalization rates. Per capita income was significantly negatively associated with ACSC admission rates only for incomes up to \$25,000 ($p = .00$). In zip codes with per capita incomes greater than \$25,000, there was no relationship between income and preventable hospitalization rates. Nonwhite race was associated with increased ACSC admission rates ($p = .00$). Zip codes with high per capita personal income levels had high percentages of the population with high school diplomas

($r=.93$) and baccalaureate degrees ($r=.92$), respectively. Education level was too highly correlated with per capita personal income to be independently estimated.

Delia (2003) performed a retrospective analysis of state data to compare patterns of admissions for ACSCs by demographic and socioeconomic factors. The sample included children and adults, less than 65 years old, discharged in New York State during 1990-1998. ACSC admissions were analyzed for trends over time, persistence within zip codes over time and variation between and within socioeconomic levels. Gastroenteritis was one of 23 ACSCs included. Admission rates were calculated per 1,000 population.

A multivariate analysis controlling for age and gender found that total population, increased black or Hispanic population, increased births to unwed mothers, increased non-ACSC admissions and rural residence were all significantly positively associated with admission rates ($p<.05$). Median income was significantly negatively associated with admission rates ($p<.01$). As a percentage of total admissions, admissions for ACSCs rose by 4%. Persistently high rates were found in low-income zip codes.

Primary Care

Healthcare Resources

Appropriate and timely use of primary and preventive care services is a means to reduce potentially avoidable admissions. Due to the nature of ACSCs, the link to primary care is based on expert clinical knowledge and observational data. Research has focused on variations in ACSC admissions based on the availability of primary care resources and utilization of primary care services.

Epstein (2001) performed a retrospective analysis of state data to determine the relationship between providers (hospitals, physicians and public ambulatory clinics) availability and characteristics and ACSC admission rates. The sample included children and

adults discharged in Virginia during 1995-1997. Zip codes were grouped into 435 clusters with populations of at least 2,000. Population and provider characteristics of zip code clusters were controlled to test the effect primary care providers on ACSC admission rates. Clusters with household incomes of less than \$15,000 were categorized as low-income. The ACSC admission rate was calculated per 1,000 population. Gastroenteritis was included as one of fifteen ACSCs.

Multivariate analysis found that availability of ambulatory clinics was negatively associated with ACSC admission rates for low-income clusters. Clusters in medically underserved areas (MUA) with a federally qualified health center (FQHC) had on average 5.8 fewer admissions per 1,000 population compared to clusters in MUAs without a FQHC ($p=.03$). Low incomes, elderly females, shorter distances to a hospital, lower hospital salaries and fewer college educated residents were significantly positively associated with ACSC admission rates ($p<.05$). Primary care physician supply was not significantly associated with preventable hospitalization rates.

Falik, Needleman, Wells and Korb (2001) performed a retrospective analysis of Medicaid claims data from multiple states to assess the effect of FQHCs on the likelihood of an ACSC admission or ACSC emergency department (ED) visit. The sample included children and adults, less than 65 years old, enrolled in Medicaid during 1994. The states included were Kentucky, Maine, Missouri, Pennsylvania and Washington. A random sample of 24 service areas was stratified to reflect the national rural-urban mix of FQHCs.

The sample included Medicaid enrollees stratified by the percentage of primary care received from FQHCs (more than 50% vs. 50% or less). Twenty chronic and acute ACSCs were included. Gastroenteritis was one of eleven acute ACSCs included and accounted for

20% of admissions (second only to asthma). Case mix, age, race, gender, cash assistance-welfare status, months in the sample and rural-urban residency were controlled.

Multivariate analysis revealed patients who received more than 50% of their primary care from FQHCs had a significantly lower likelihood of an ACSC admission or readmission (OR=0.80 and 0.43 respectively, $p<.01$). FQHC patients were also less likely to have had an ACSC ED visit or an ACSC ED visit without a prior office visit (OR=0.87 and 0.76 respectively, $p<.00$). FQHC center patients averaged more office visits (1.56 versus 1.47 visits, $p=.02$). For the entire sample, children less than five years old and those with rural residences were significantly more likely to have an ACSC admission (OR=2.66, 2.58 and 1.27 respectively, $p<.01$).

Hakim and Bye (2001) performed a retrospective analysis of Medicaid claims in three states to assess the relationship between ACSC admissions and well-child visits and immunizations in young children. The sample included children less than two years old enrolled in Medicaid since birth during 1990 and followed for three years. The states included California, Georgia and Michigan. Gastroenteritis was one of four ACSCs included. Chronic and acute illnesses, patient socioeconomic status and county characteristics related to economic conditions and health care resources were controlled. Admission rates were calculated per 1,000 children.

The overall ACSC admission rate was highest in Georgia followed by Michigan and California (160.9, 120.0 and 70.0 per 1,000 children respectively). For all three states, the overall ACSC admission rate was 117 per 1,000 children and the gastroenteritis/dehydration admission rate was 14 per 1,000 children.

ACSC admission rates were not consistent with population size. In California, the majority of children were Hispanic, but the highest ACSC admission rate was found for

black children (83.9 per 1,000 children). In Georgia, the majority of children were black, but white children had the highest ACSC admission rate (181.8 per 1,000 children). In Michigan, the majority of children were white, but blacks had the largest ACSC admission rate (127.3 per 1,000 children). The Aid to Families with Dependent Children group which represented the poorest group of children had the highest avoidable hospitalization rate of any eligibility group in all states (84.7, 174.7 and 132.0 per 1000 children for California, Georgia and Michigan respectively).

Multivariate analysis revealed that being up-to-date for age in the recommended number of well-child visits was associated with a statistically significantly lower hazard ratio (HR) of an avoidable hospitalization in all three states (HR=0.52 in California, 0.54 in Georgia and 0.74 in Michigan). Up-to-date for age in recommended immunizations was associated with fewer avoidable hospitalizations in Michigan (HR=0.88) only. More pediatricians per 10,000 population was associated with fewer avoidable hospitalizations in Georgia (HR=0.74) and Michigan (HR=0.92).

Ricketts, Randolph, Howard, Pathman and Carey (2001) performed a retrospective analysis of state data to examine the relationship between ACSC admissions, primary care resources and economic conditions. The sample included children and adults discharged in North Carolina during 1994. Zip codes were grouped into clusters surrounding primary care providers and called primary care service areas. Primary care providers included primary care physicians and subsidized clinics. Gastroenteritis was one of 22 ACSCs included. Admission rates were calculated per 1,000 population.

ACSCs comprised 16.9% of all admissions. Of the top five ACSCs for all ages, asthma and pneumonia were the two most relevant for children. Children were included in the group aged less than 65 years old. In this group, the overall ACSC admission rate was

101.5 per 1,000 population and was moderately negatively correlated with per capita income ($r=-.51$) and positively correlated with total hospital admission rate ($r=.69$).

Multivariate analysis found no significant relationship between the ACSC admission rates in primary care service areas and primary care physician supply or the presence of a subsidized clinic. The ACSC admission rate was significantly ($p<.05$) positively associated with total hospitalization rate, per capital income and percentage minority population. The percentage employed was almost significantly ($p=.06$) associated with the ACSC admissions rate.

Flores, Milagros, Chaisson and Sun. (2003) performed a retrospective analysis of perspectives on the ACSC admission avoidability. The sample included the parents, primary care physicians and inpatient attending physicians of children, less than nineteen years old, admitted to a Boston hospital over a 14-month period in 1997-1998. Gastroenteritis was one of 16 ACSCs included.

Six ACSCs (asthma, dehydration/gastroenteritis, pneumonia, seizure disorder, skin infections and urinary tract infections/pyelonephritis) accounted for 90% of ACSC admissions. For all ACSC admissions, almost half of the parents cited physician-related reasons as to why the admission was not avoided with the topmost reasons being inadequate/no interventions for the child and lack of child/family education. In contrast, around 70% of primary care physicians cited parent/patient-related reasons as to why the admission was not avoided with the two topmost reasons being medication-related (i.e., adherence problems, ran out and did not refill) and delayed or lack of follow-up.

Dehydration/gastroenteritis compromised 16% of all ACSC admissions, second only to asthma. The proportion of admissions for gastroenteritis perceived as avoidable varied according to the source. Parents, primary care physicians and inpatient attending physicians

perceived that 26%, 30% and 20% of gastroenteritis admissions were avoidable respectively. Multivariate analysis found admissions for asthma, child aged eleven years and older and family income in the third quartile (\$12,144-\$18,000) were significantly more likely to be perceived as avoidable by all three sources (ORs ranged from 2.4-3.2, $p < .05$).

Bermudez and Baker (2004) performed a retrospective analysis of state discharge data to assess the relationship between the State Children's Health Insurance Program (SCHIP) enrollment and ACSC admissions. The sample included children, 1-18 years, residing in urban counties of California and discharged during 1996-2000. Gastroenteritis was one of seven childhood ACSCs included. Non-ACSC admissions for appendicitis without rupture were used as a control group. Annual admission rates were calculated per 100,000 population.

The overall ACSC hospitalization rate was 28.9 per 100,000 population. Multivariate analysis found SCHIP enrollment, percentage of high school graduates and total population were significantly negatively associated with ACSC admission rates ($p < .01$). Fixed characteristics of counties, racial groups, trends over time and other demographic and health system variables were controlled.

Laditka, Laditka and Probst (2005) performed a retrospective analysis of discharge data from 20 states to assess the relationship between physician supply and county ACSC admission rates. The child sample included discharges, 0-17 years old discharged during 1999. Gastroenteritis was one of 13 ACSCs included.

ACSCs accounted for 10.5% of all hospitalizations. Multivariate analysis found the hospital bed rate, ED visit rate, population density and the proportions of blacks, those with low educational attainment and low-income households (<\$15,000) were significantly positively associated with county ACSC admission rates. Physician supply per 100,000

population was significantly negatively associated with county ACSC admission rates and the largest contributor ($b = -0.24, p < .00$) to reducing admissions. Increasing the physician supply by one standard deviation decreased the mean ACSC admission rate by 13.6%.

Managed Care

Managed care represented a relatively recent change in the management of health care that developed to control rapidly rising health care costs. Managed care had different forms (e.g., health maintenance organization [HMO], preferred provider organization and point of service), all of which change the focus of health care from specialty care providers in acute care settings to primary care providers in outpatient settings. Managed care was designed to promote primary care activities and reduce expensive hospitalizations.

Gadomski, Jenkins and Nichols (1998) performed a retrospective analysis of state data to evaluate potentially avoidable hospitalizations in Maryland's Medicaid program during 1989-1993. The sample included children, aged eighteen years or younger, enrolled and not enrolled in Maryland Access to Care (MAC) program. The MAC program was a Medicaid managed care, fee-for-service gatekeeper program with assigned primary care providers that performed early periodic screening, diagnosis and treatment visits. They analyzed Medicaid claims to identify factors related to hospitalizations and outpatient visits. Avoidable hospitalizations were defined as admissions for ACSCs that were not preceded by either an outpatient or pharmaceutical primary care claim. Gastroenteritis was one of eighteen pediatric conditions included.

Multivariate analysis found that MAC-enrolled children were more likely to have had a preventive visit, ED visit and any type of outpatient visit (OR=2.19, 1.44 and 2.58 respectively) compared to non-MAC enrolled children. MAC-enrolled children were less likely to have had an avoidable hospitalization, ACSC admission or any hospitalization

(OR=0.89, 0.96 and 0.81 respectively). The probability of an avoidable hospitalization was inversely related to the number of preventive care visits and directly related to the number of ED visits.

Friedman and Basu (2001) performed a retrospective analysis of county data to assess the relationship between ACSC admissions and HMO enrollment, insurance coverage, availability of primary care, severity of illness and distance to a hospital. The sample included children, 0-19 years old, residing in New York, but hospitalized in New York, New Jersey, Pennsylvania or Connecticut during 1994. Gastroenteritis was one of seventeen ACSCs included. ACSC admission rates were calculated per 1,000 child population.

The age-adjusted, ACSC admission rate was 11.36 per 1,000 child population. The proportion of Medicaid/self-pay admissions, non-white population and hospital inpatient capacity were significantly positively associated with ACSC admission rates ($p<.05$). The proportion of private HMO admissions, primary care physician rate per 1,000 population and average distance to a hospital were significantly negatively associated with ACSC admission rates ($p<.05$).

Bindman, Chattopadhyay, Osmond, Huen and Bacchetti (2005) performed a retrospective analysis of California Medicaid claims data during 1994-1999 to assess the effect of managed care on ACSC admissions. The sample included children and adults, less than 65 years old, eligible for Temporary Aid for Needy Families (TANF) in Medicaid. TANF-eligible, fee-for-service enrollees were compared to voluntary and mandatory Medi-Cal enrollees. Medi-Cal was the Medicaid managed care program. They hypothesized that, if managed care improved access to ambulatory care, managed care enrollees would have lower rates of ACSC admissions compared to fee-for-service enrollees. The authors stated

that all commonly accepted ACSCs for children and adults were included but no specific conditions were identified. Admission rates were calculated per 10,000 enrollees.

During the study period, the percentage of managed care enrollees increased from 23% to 78% with most of the increase due to mandatory managed care enrollment. Mandatory and voluntary managed care enrollees had significantly lower average monthly ACSC admission rates compared to fee-for-service enrollees (4.95 and 4.10 vs. 6.43 per 10,000 enrollees, $p < .00$). The relative decrease in ACSC admissions associated with mandatory managed care versus fee-for-service was significantly larger for blacks, Asians and Latino admissions compared to the relative difference for whites. The ACSC admission rate was higher in mandatory managed care than in voluntary managed care for all groups except Asians who participated at low rates in voluntary managed care.

Zhan, Miller, Wong and Meyer (2005) performed a retrospective analysis of discharge data from 22 states to assess the relationship between HMO penetration and preventable hospitalizations. The sample included discharges of all ages during 1998. Gastroenteritis was one of 14 ACSCs included. Measures of HMO competition and hospital compensation were included as instrumental variables to correct for endogeneity bias in HMO penetration.

Multivariate analysis found that advanced age, female, poverty, poor health, more hospital beds per capita and fewer primary care physicians per capita were associated with significantly more ACSC admissions. Increased HMO penetration was associated with significantly fewer ACSC admissions. The estimated effect of HMO penetration was largest for pediatric gastroenteritis admissions relative to the other ACSCs.

Summary

Many findings of these studies were consistent, however, some were not. Many studies included only children or ran a separate model for the children to examine the relationship between predictors and ACSC admissions. Regardless of the level of data, increased ACSC admissions were generally associated with young age, low-income, rural residence, non-white race/ethnicity, lower-educational attainment, increased hospital bed capacity, increased ED visits and shorter distances to a hospital. Managed care was consistently associated with lower ACSC rates. Findings related to primary care resources and insurance status were mixed. Despite the link between higher ACSC admission rates and low-income, some evidence was found that this relationship disappeared at incomes higher than \$25,000 (Cable, 2002). Physician and clinic supply were associated with lower ACSC admissions or had no effect.

Gaps and Limitations

Despite the volume of evidence regarding ACSC admissions, there was limited information about factors which are associated specifically to pediatric gastroenteritis. Almost all studies evaluated the effect of predictors on a group of ACSCs. Gastroenteritis was included in a group of ACSCs ranging from 1-28 conditions or categories. In studies that included adults, many of the specific ACSCs were not relevant to children. The pattern of findings for pediatric gastroenteritis studied independently differed from the pattern found when ACSCs were studied as a group. For pediatric gastroenteritis studied independently, higher admission rates were found in children who were young, white, privately insured and high-income areas (Parker & Schoendorf, 2000).

All the studies were retrospective and observational and faced limitations associated with these methods. Administrative data are limited by privacy requirements requiring

suppression of certain data elements and data quality within and across hospitals.

Observational data cannot produce precise estimates of the proportion of admissions that are truly preventable and relationships cannot be interpreted as causal.

Chapter Three: Method

Introduction

This study assessed the relationship between county pediatric gastroenteritis admission rates and county characteristics in Florida during 1995-2002. This project was a secondary analysis of de-identified data and not human subject research, therefore, received expedited review. Approval was obtained by Institutional Review Board of the University of South Florida in Tampa and All Children's Hospital (ACH# 03-0938). This work was supported in part by the Pediatric Clinical Research Center of All Children's Hospital and the University of South Florida and the Maternal and Child Health Bureau, R60 MC 00003-01, Department of Health and Human Services, Health Resources and Services Administration. County characteristics included measures of socioeconomic status, healthcare resources and managed care penetration. This chapter begins with the sampling procedures, includes all operational definitions and data sources and ends with the analytic plan.

Sample

Inclusion Criteria

The sample included all 67 Florida counties during the eight-year period, 1995-2002. Pediatric gastroenteritis hospital discharges in each county were identified as all children, 0-17 years old, discharged from a community hospital with one of the following diagnoses: 1) primary diagnosis of gastroenteritis or 2) a primary diagnosis of dehydration accompanied by a secondary diagnosis of gastroenteritis. The inclusion of children with dehydration and gastroenteritis reflected the most recent revision of the

pediatric gastroenteritis definition (AHRQ, Measures of Pediatric Healthcare Quality, 2006). The specified age range in the definition provided by AHRQ was 3 months to 17 years old, however, the age range for this project was 0-17 years old because Florida discharge data do not provide age in months or days for children under one year old. An age of zero is any child less than one year old at the time of admission.

Exclusion Criteria

Three groups of children were excluded because a hospitalization for acute gastroenteritis is likely necessary and *not* considered avoidable. The first group excluded was newborns and other neonates (i.e., less than 30 days old). The second group excluded was children hospitalized with conditions related to pregnancy, childbirth and the puerperium (i.e. the six-week period between childbirth and the return of the womb to its normal state). The third group excluded was children with any diagnosis code indicating gastrointestinal abnormalities or bacterial gastroenteritis. The exclusion of this third group of children reflected a revision to the definition. Exclusion of these groups of children was done using diagnosis coding.

Finally, children with codes indicating transfer from another facility were excluded. This was done to avoid counting one child admitted to a hospital and then transferred to another hospital as two admissions. The dataset does not provide a way to track an individual child across multiple hospitals to avoid double counting.

The recent definition no longer recommended excluding children with diagnoses or procedures indicating immunocompromising conditions, organ transplantation and cancer. Expert review concluded these children have no increased risk for admission with proper primary care. Inclusion and exclusion diagnosis and procedure codes (Appendix A and B)

used to identify valid discharges for pediatric gastroenteritis were specified by AHRQ (AHRQ, Measures of Pediatric Healthcare Quality, 2006).

Discharge Level Data

Zip codes were used to place all pediatric gastroenteritis discharges within their county of their residence. There were 1,449 valid Florida zip codes all of which occur between 32003 and 34997. Of the available Florida zip codes, 173 or 11.9% of the codes intersected 2-3 counties. Zip codes that intersected multiple counties were assigned to the county in which the greatest proportion of that zip code occurred. A brief descriptive analysis of the children hospitalized for gastroenteritis was performed to assess the characteristics of children admitted for gastroenteritis and their hospital stays.

Measures and Data Sources

Outcome Measure

The outcome measure was the county pediatric gastroenteritis hospital admission rate per 100,000 child population. Annual county rates were calculated as the number of pediatric gastroenteritis discharges (0-17 years old) per 100,000 child population. The number of discharges for pediatric gastroenteritis in each Florida county during 1995-2002 was obtained from the State Inpatient Databases (SID). The Florida SIDs were part of the Healthcare Cost and Utilization Project (HCUP) sponsored by AHRQ and Florida's Agency for Health Care Administration. The Florida SIDs contained the "universe" of inpatient discharges from community hospitals defined as *nonfederal, short-term, general and other specialty hospitals, excluding hospital units of institutions*. Federal, long-term and psychiatric hospitals, substance abuse treatment facilities and hospitals units within institutions (e.g., prison healthcare facilities) were not included. In 2002, the Florida SID contained discharges from 189 community hospitals (AHRQ Overview of the SID, 2006).

Annual county population estimates were provided by the Florida Legislature's Office of Economic and Demographic Research (EDR) and were based on United States Census Bureau (USCB) data (EDR, 2005). Annual county population estimates by age were available for each year of the study period.

Explanatory Variables

Proportion of Minority Children. Although the concepts of race and ethnicity have evolved into separate concepts, they were treated as a single variable to be consistent with state discharge data and the majority of the census data obtained for the study period. The county proportion of minority children included all children of non-white race/ethnicity in the child population. Annual county estimates of non-white children in the child population (0-17 years old) were obtained from the EDR. Population estimates by race/ethnicity were available for all years of the study period.

Proportion of Young Children. The proportion of children (0-4 years old) has been associated with increased ACSC admissions. Annual county estimates of children 0-4 years old in the child population (0-17 years old) were obtained from the EDR. Population estimates by age were available for all years of the study period. The county proportion of young children was included to control for the effect of age on admission rates and not related to a hypothesis.

Proportion of Male Children. Annual estimates of the proportion of males in the child population (0-17 years old) were obtained from the EDR. Estimates were available for all years of the study period. The county proportion of male children was included to control for the effect of gender on admission rates and not related to a hypothesis. Annual county estimates of male children in the child population (0-17 years old) were obtained from the EDR. Population estimates by gender were available for all years of the study period.

Proportion of Children in Poverty. Poverty status was determined annually by family size, income and federal poverty thresholds (USCB Poverty Thresholds, 2005). Poverty thresholds were used to determine eligibility for government health care and welfare programs. Annual estimates of the child population (0-17 years old) living in poverty were obtained from the Small Area Income and Poverty Estimates (SAIPE) program from the USCB (USCB SAIPE, 2005). Poverty estimates were available for all years of the study period except 1996.

Median Household Income. Median household income for a county was the midpoint of household income for all residents. Annual county estimates of median household income rounded to the nearest dollar were obtained from the USCB SAIPE program (USCB SAIPE, 2005). Median household income estimates were available for all years of the study period except 1996.

Rural-Urban Level. Rural-urban level has been associated with decreased access and availability of primary healthcare services. Generally, there are fewer health care providers of all types in rural areas. County rural-urban level was defined by its rural-urban continuum code (RUCC). RUCCs were determined by the U.S. Department of Agriculture's Economic Service Research (ESR, 2003) based on population size and proximity to a metropolitan area. RUCCs assigned by the government ranged from 0-9 with higher values indicating increasingly rural areas. A constant value (equal to 1) was added to avoid a value of zero and rural-urban levels were defined as follows

1 = central counties of metropolitan areas of 1 million population or more

2 = fringe counties of metropolitan areas of 1 million population or more

3 = counties in metropolitan areas of 250,000 to 1 million population

4 = counties in metropolitan areas of fewer than 250,000 population

5 = urban population of 20,000 or more, adjacent to a metropolitan area

6 = urban population of 20,000 or more, not adjacent to a metropolitan area

7 = urban population of 2,500 to 19,999, adjacent to a metropolitan area

8 = urban population of 2,500 to 19,999, not adjacent to a metropolitan area

9 = completely rural or less than 2,500 urban population, adjacent to a metropolitan area

10 = completely rural or less than 2,500 urban population, not adjacent to a metropolitan area

RUCCs 1-4 were metropolitan areas and 5-10 were nonmetropolitan areas. County RUCCs were available for all years and did not change during the study period.

Primary Care Physician Supply. Primary care physicians included physicians who reported their specialty as pediatrics or family practice. The annual physician supply rate was defined as the number of pediatric primary care physicians per 100,000 child population. County physician supply was available for 1995, 2000 and 2001 in the 2003 Area Resource File (ARF). The ARF is a national county-level dataset with information regarding health resources, professions, training programs, facilities, resource scarcity and health status (Quality Resource Systems, n.d.). The physician rate was expressed per 100,000 child population to be consistent with the outcome measure.

Health Clinic Supply. Health clinic supply was defined as the number of FQHCs and rural health clinics (RHC) per 100,000 child population. RHCs and FQHCs must be located in medically underserved areas. Both types of clinics provide similar services including primary care and use mid-level health care providers (i.e., physician assistants and nurse practitioners). Clinics cannot be licensed as both a RHC and FQHC (Centers for Medicare and Medicaid Services, 2005). The number of RHCs and FQHCs was available for 1999,

2000 and 2001 from the 2003 ARF. The health clinic supply rate was expressed per 100,000 child population to be consistent with the outcome measure.

Community Hospital Supply. Community hospital supply was the only measure of acute care service availability which could have affected ACSC admissions especially for children without a medical home. Hospital supply was defined as the annual number of community hospitals in a county per 100,000 child population. The county supply of community hospitals was available for 1995, 2000 and 2001 from the 2003 ARF. The community hospital rate was expressed per 100,000 child population to be consistent with the outcome measure.

Health Maintenance Organization Enrollment. County HMO enrollment was an index of managed care penetration. County HMO enrollment was defined as the proportion of the population (all ages) enrolled in a commercial, commercial Medicaid or commercial Medicare HMO. Quarterly HMO enrollment reports were obtained from the Office of Insurance Regulation (2006) and the average number of HMO enrollees for all four quarters was used to represent the annual number of HMO enrollees. Enrollment data was available for the years 1999-2002. The proportion of HMO enrollees of all ages was used because data were not available for children only.

Procedures and Analysis

Univariate Analysis

County-level characteristics were imported into SPSS to create the county file. A record was created for each year and county during the study resulting in a file with 536 observations. A univariate analysis was performed to provide descriptive statistics, assess intercorrelations among explanatory variables and evaluate variable distributions.

Descriptive statistics included the number of cases (N), means, standard deviations (SD) and

minimum and maximum values for all variables. Data was screened for plausible values and missing data.

Bivariate intercorrelations among explanatory variables were estimated using Pearson's product moment correlation (r) with a two-tailed test of significance and alpha at .05. Intercorrelations were examined to identify multicollinearity among explanatory variables which may lead to unstable estimates. Distributions were examined for normality.

Multivariate Analysis

Missing Data. The first step of the multivariate analysis was to address availability of county characteristics each year (Table 1). Missing data were systematically missing across all counties in a year due to the availability within data sources. Missing data were more prevalent in measures of primary care resource availability compared to socioeconomic status measures.

Multiple substitution methods were considered, however, because of the differences in the extent of missing data between socioeconomic status factors and healthcare resources a combination of data substitution methods was eventually chosen. The details regarding data substitution are discussed in the section titled *Analytic Steps*.

Multilevel Modeling. Files were imported into multilevel modeling software, HLM 6.02. Multivariate analysis of 67 Florida counties with repeated, annual measures was performed using HLM to assess variability across individual occasions and counties and over time. In longitudinal designs, repeated observations (occasions) from multiple years are grouped within counties. Multilevel modeling was chosen for the multivariate, analytical technique because it can adjust for varying intercepts and slopes in grouped, longitudinal data and any pattern of correlated errors across time points.

Table 1: Availability of County Characteristics by Year

Characteristic	1995	1996	1997	1998	1999	2000	2001	2002
Minority Race/Ethnicity	+	+	+	+	+	+	+	+
Age	+	+	+	+	+	+	+	+
Gender	+	+	+	+	+	+	+	+
Child Poverty	+	--	+	+	+	+	+	+
Median Household Income	+	--	+	+	+	+	+	+
Rural-Urban Level	+	+	+	+	+	+	+	+
Physician Supply	+	--	--	--	--	+	+	--
Clinic Supply	--	--	--	--	+	+	+	--
Hospital Supply	+	--	--	--	--	+	+	--
HMO Enrollment	--	--	--	--	+	+	+	+

Note: (+) indicates data available for all counties. (--) indicates data not available for any county.

In this project, there were 536 (8 years multiplied by 67 counties) occasions and 67 counties (groups). The goal was to predict county pediatric gastroenteritis admission rates based on variability at two levels, occasions (Level-1) and counties (Level-2). A two-level, random coefficients regression model (intercepts and slopes allowed to vary) was used to adjust for differences among individual occasions and counties. In a two-level model, values of Level-1 explanatory variables varied across each time point and county, while values of Level-2 explanatory variables only varied across counties but stayed the same across each time point. The basic equations for the two-level model were

$$\text{Level-1 Equation: } Y_{ij} = \pi_{0j} + \pi_{1j} X_{ij} + e_{ij}$$

$$\text{Level-2 Equations: } \pi_{0j} = \beta_{00} + \beta_{01} W_j + r_{0j} \quad (\text{intercept})$$

$$\pi_{1j} = \beta_{10} + \beta_{11} W_j + r_{1j} \quad (\text{slope})$$

As seen in the basic equations, all Level-1 parameters were functions of Level-2 explanatory variables and variability. The basic Level-1 equation adjusted for variability of individual occasions. At Level-1, the outcome (Y_{ij}) was a function of the intercept (π_{0j}) and the effect (π_{1j}) of the Level-1 explanatory variable (X_{ij}) and random error (e_{ij}) among individual occasions.

The Level-2 equations modeled variation in intercepts and slopes due to county variation. The intercept for each county (π_{0j}) was a function of the mean value of the outcome variable in each county (β_{00}), the effect (β_{01}) of the Level-2 variable (W_j) and random error at the group level (r_{0j}). The slope for each county (π_{1j}) was a function of the mean value for the slope in each group (β_{10}), the effect (β_{11}) of the Level-2 variable (W_j) and random error at the group level (r_{1j}). The basic equations are combined to form the full multilevel model.

$$Y_{ij} = \underbrace{[\beta_{00} + \beta_{01} W_j + \beta_{10} X_{ij} + \beta_{11} W_j X_{ij}]}_{\text{Fixed Effects}} + \underbrace{[r_{0j} + r_{1j} X_{ij} + e_{ij}]}_{\text{Random Effects}}$$

The full model contained both fixed and random effects. Fixed effects did not vary and applied to all groups. Within the fixed effects portion was a term that reflected the effect of a cross-level interaction between a Level-1 and Level-2 variable ($\beta_{11} W_j X_{ij}$). Random

effects contained the variance components associated with differences in the intercept across individual occasions (e_{ij}) and groups (r_{0j}) and the effect of the Level-1 variable ($r_{1j}X_{ij}$) across groups.

The final value for the intercept was the average across all occasions and counties. Slopes across counties were assessed two ways; 1) by constraining all counties to a similar effect and estimating only the fixed effects of explanatory variables across counties and then 2) allowing the effect (slopes) to vary across counties and estimating both fixed and random effects (i.e., variance components). In addition to cross-level interactions, all two-way interactions between Level-1 variables were assessed.

The terms in the mixed equation for any model were determined by the fixed effects of Level-1 and Level-2 variables, which slopes of Level-1 variables (if any) were allowed to vary across counties and which interactions (if any) were included.

Analytic Steps.

Missing data substitution was done before analysis. One year of data (1996) was missing for median income and proportion of children in poverty. For each county, the mean value was calculated from its 1995 and 1997 data and substituted for the missing values in 1996.

There were four years of missing data for proportion of HMO enrollment and five years of missing data for the number of physicians, hospitals and clinics in each county. Since at least 50% of the data were missing for these variables, any standard method for data substitution would lead to minimal or no variation of individual observations. For this reason, the decision was made to construct these measures as Level-2 variables. For each county, an average rate for each resource was calculated for the study period.

Once data substitution was complete, Level-1 variables were; median income, proportions of children in poverty, aged 0-4 years old, male and with minority race/ethnicity. Level-2 variables were; rural-urban level, proportion of HMO enrollment and the hospital, physician and clinic supply rates. No constraints were imposed on the pattern of correlations across counties.

Null Model. Step one included an analysis the null or intercept-only model. All analyses were done using full maximum likelihood estimation procedures and alpha at .05. The null model contained no explanatory variables. The null model was important for two reasons; calculation of the intraclass correlation (ρ) and baseline deviance score (Hox, 2002, pp.11-36).

Although the null model did *not* explain any of the variance in the outcome, it decomposed the variance into two independent components; variance explained by individual occasions and variance explained by the grouping structure (county). These components were necessary to calculate the intraclass correlation (ρ) using

$$\rho = \sigma_{u_{0j}} / \sigma_{u_{0j}} + \sigma_{e_{ij}}$$

The intraclass correlation indicated the proportion of variance explained by the grouping structure in the data and was interpreted as the expected correlation between any two randomly chosen observations within the same county.

The null model also provided the baseline deviance value or an index of model fit. The deviance was calculated using

$$\text{deviance} = -2LL$$

where LL equaled the log of the likelihood. The deviance value for any one model has no direct interpretation. Instead, deviances were used to compare the fit of nested models (one model a subset of the other) with lower deviance values indicating better fit. It is important to note that, the model with more parameters will *always* have a lower deviance than one with fewer parameters (Luke, 2004, pp.34).

The difference in deviance scores between two nested models, however, can be tested to see if the model with more parameters fits the data significantly better than the one with fewer parameters. The difference in the deviance scores were compared to a chi-square distribution with alpha at .05 and degrees of freedom equal to the difference in the number of parameters being estimated (Luke, 2004, pp.34). In other words, a model with more parameters will always have a lower deviance value compared to a nested model (the same model but with fewer parameters), but not necessarily have significantly improved fit.

Time Model. Step two involved adding a variable in the model for the linear trend over time. Time was coded 1-7 starting at 1995. This coding was recommended when the time structure for correlated errors is generated automatically by the multilevel software (Hox, 2002, pp.73-102). First, the fixed effects of time were assessed (intercepts varied, slopes constrained). Next, slopes were allowed to vary randomly across groups to assess the variance associated with time (with random slopes).

Final Model. Step three involved adding all explanatory variables and non-linear trends over time (quadratic and cubic) in the model to determine the fixed effects of each. Non-linear trends over time were assessed using the method of orthogonal polynomials (Keppel, 1991). All explanatory variables were centered on the grand mean. With grand mean centering, the intercept was interpreted as the expected value when an observation or

group has the “average” value for all explanatory variables. Values were centered to give a meaningful interpretation to a variable at a value of zero and ease interpretation. A model with variables centered on the grand mean was essentially equivalent the model with uncentered variables (Hox, 2002, pp.49-71).

Next, all Level-1 explanatory variables were assessed individually for significant variation across counties. Only those explanatory variables with a significant variance component were allowed to have varying slopes included in the final model.

Step four involved an individual examination of all possible two-way interactions: within Level-1 (e.g., median income and minority child rate) and cross-level (e.g, median income and physician supply). Interaction terms were calculated using variables centered on the grand mean to minimize multicollinearity with the original variables. Only interactions with significant fixed effects at this step were in the final model.

Model Fit

In addition to deviance values, model fit was assessed using Akaike’s Information Criterion (AIC) and the Bayesian Information Criterion (BIC). Both are general fit-indices used to compare models and assumed that models being compared were fit to the same data using the same estimation method (Hox, 2002, pp.37-48). The AIC included a penalty for the number of parameter estimates and was calculated using

$$AIC = d + 2q$$

where d equaled the deviance, q equaled the number of parameter estimates in the model. The BIC included a penalty for the number of parameter estimates and complexity of the model. The BIC was calculated using

$$\text{BIC} = d + q \ln(N)$$

where d equaled the deviance, q equaled the number of parameter estimates, $\ln(N)$ equals the natural log of the sample size at Level-1 ($N=536$). Like the deviance, AIC and BIC values had no direct interpretation. Values of two models were compared and lower values indicated better fit (Hox, 2002, pp.37-48).

Variable Transformation

The preceding analytic steps assumed a normal distribution of the explanatory variables. Distributions found to have significant skewed were appropriately transformed to more closely fit a normal distribution (Tabachnick & Fidell, 2001) and reassessed. Findings from the untransformed (original) variables were compared to findings from the transformed variables.

Variance Explained

The proportion of explained variance was complex. The squared multiple correlation (R^2) that exists in standard regression techniques could not be calculated due to the hierarchical design because each level contributed separately to proportion of variance explained. A method analogous to R^2 approximated the proportionate decrease in unexplained variance in the intercept at each level (Hox, 2002, pp.73-102).

At Level-1, R^2 was interpreted as the proportionate reduction of error variance in predicting admission rates at individual occasions. At Level-2, R^2 was interpreted as the proportionate reduction of error in predicting admission rates at the group (county) level. Calculating the proportionate reduction in variance of the final model was done using

$$R^2 = \frac{\sigma_{ij}(\text{null model}) - \sigma_{ij}(\text{final model})}{\sigma_{ij}(\text{null model})} \quad (\text{Level-1})$$

$$R^2 = \frac{\sigma_{0j}(\text{time model}) - \sigma_{0j}(\text{final model})}{\sigma_{0j}(\text{time model})} \quad (\text{Level-2})$$

In longitudinal designs, baseline variance for Level-1 was the individual occasion-level variance component (σ_{ij}) from the null model. Baseline variance for Level-2 was the county-level, intercept variance (σ_{0j}) from the model with the fixed effect of time added.

Chapter Four: Findings

Introduction

The number of Florida children admitted for acute gastroenteritis ranged from a minimum of 7,711 in 1999 to a maximum of 8,612 in 2001. The total number of admissions was 64,072 over the study period. This section contains a brief description of children hospitalized for gastroenteritis followed by the findings of the descriptive and multivariate analysis.

Gastroenteritis Admissions

Over the entire study period the majority of children were male (53.0%), aged 0-4 years old (78.6%), white 55.1%, had some form of insurance coverage (93.7%), were routinely discharged home (99.0%) and did not have any intensive care charges (98.2%). The majority of admissions occurred between January and June (69.9%). Characteristics of children admitted with gastroenteritis and their hospital stays (length of stay, total charges) by year are in Tables 11 and 12 (Appendices C and D). Inpatient deaths for the entire period were few and no findings were reported per the data use agreement (prevented reporting findings based on $N < 10$).

Of all the pediatric gastroenteritis admissions in Florida during the study period, the county of residence could not be identified for 2,386 or 3.7% of cases because of missing or invalid zip codes.

County Characteristics

Univariate analyses provided the overall means, standard deviations (*SD*) and minimum and maximum values for all variables (Table 2).

Table 2: Descriptive Characteristics of Sample: Florida Counties 1995-2002

Characteristic	Mean	<i>SD</i>	Minimum	Maximum
Level 1 (<i>N</i> =536)				
Gastroenteritis Admission Rate	205.72	147.39	0.00	1008.51
Minority Child Proportion	.20	.12	.05	.71
Children (0-4 years Proportion)	.26	.02	.03	.44
Male Child Proportion	.52	.01	.38	.55
Child Poverty Proportion	.22	.06	.09	.39
Median Income	\$32,667	\$6,150	\$20,367	\$52,244
Level-2 (<i>N</i> =67)				
HMO (all ages) Proportion	.18	.13	.26	.48
Rural-Urban Level	5.15	3.76	1	10
Physician Supply	111.39	70.88	0.00	472.94
Clinic Supply	29.60	37.55	0.00	177.94
Hospital Supply	10.07	9.78	0.00	48.53

Note: Gastroenteritis admission rate and supply of physicians, clinics and hospitals are per 100,000 child population. Values rounded to the nearest hundredth.

For county characteristics by year using the original data see Table 13 (Appendix E).

Individual county admission rates varied dramatically from zero to 1,008.51 admissions per 100,000 child population. These rates are not directly comparable to historical pediatric gastroenteritis rates in previous reports because of the expanded definition.

Bivariate correlations among explanatory variables were generally small to moderate (see Table 14 in Appendix F). Out of 45 correlations, 40 (88.9%) were .37 or less. The most highly correlated variables were median household income and proportion

of children in poverty ($r=-.65, p<.01$). Except rural-urban level, all explanatory variables had some skew (Appendix G).

Multivariate Results

Null Model. The null (intercept only) model examined variation in gastroenteritis admission rates with no explanatory variables present. The null model was written as

$$\text{Admission Rate} = \beta_{00} + r_0 + e$$

with parameter estimates and standard errors presented in Table 3. The average admission rate across all individual occasions and counties was 205.72 admissions per 100,000 child population.

Table 3. Null Model (intercept only)

Fixed Effects	Coefficient	SE	p
Intercept, β_{00}	205.72	14.37	.00
Random Effects	Variance Component	SD	p
Intercept, r_0	12,714.70	112.76	.00
Level-1 effect, e	8,969.78	94.71	
Deviance	6,567.93		
AIC	6,573.93		
BIC	6,586.78		

Note: Level-1, $N=536$. Level-2, $N=67$. Values rounded to nearest hundredth.

Variation in admission rates across counties and individual occasions was large ($r_0=12,714.70$ and $e=8,969.78$ respectively). Variation in mean admission rates across counties was significant ($\chi^2_{(66)}=826.78, p=.00$) and larger than the component associated with individual occasions. The intraclass correlation (ρ) was 0.586 and indicated that 58.6% of the variance in admission rates was associated with county (Level-2) differences. The

remaining variance in mean admission rate was associated with differences among individual occasions (Level-1). The null model provided baseline deviance, AIC and BIC scores. The null model also provided the baseline variance at the individual level which was used to calculate the proportionate reduction in variance at that level for subsequent models.

Time Model

Fixed Effects of Time. A variable for the linear effect of time was added to the model because of the longitudinal design. First, only the fixed effect of time was estimated. This constrained the effect of time to be similar across counties (Figure 2).

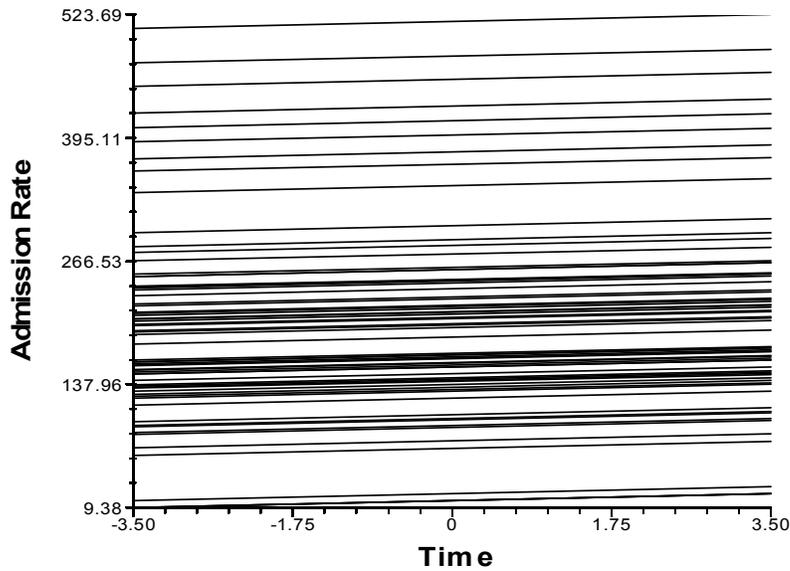


Figure 2. Fixed Effects of Time on County Admission Rates

Figure 2 depicts the relationship between the time (fixed effects) and admission rates for all 67 counties. The values on the x-axis of Figure 2 range from -3.50 to 3.50 and reflect grand mean centering. The equation for the model with only the fixed effect of time was

$$\text{Admission Rate} = \beta_{00} + \beta_{10}(\text{time}) + r_0 + e$$

with parameter estimates and standard errors presented in Table 4. When the effect of time was fixed across counties, its coefficient was non-significant ($\beta_{10}=2.07, p=.47$)

Table 4. Time Model (fixed effects)

Fixed Effects	Coefficient	SE	p
Intercept, β_{00}	205.73	14.37	.00
Time, β_{10}	2.07	2.85	.47
Variance			
Random Effects	Component	SD	p
Intercept, r_0	12,717.91	112.77	.00
Level-1 effect, e	8,944.10	94.57	
Deviance	6,566.59		
AIC	6,574.59		
BIC	6,591.72		

Note: Level-1, $N=536$. Level-2, $N=67$. Values rounded to nearest hundredth.

Minimal changes occurred in the variance components and large amounts of variance remained at the group and occasion level. Compared to the null model, variance at the county level (r_0) increased minimally (12,714.70 vs. 12,717.91) while variance at the individual occasion-level (e) decreased minimally (8,969.78 vs. 8,944.10 respectively). Increases in the same variance component across models can occur in multilevel models due to the underlying statistical sampling procedures (Hox, 2002, pp.73-102).

Compared to the null model, addition of the fixed effects of time did *not* significantly improve model fit compared to the null model as seen in the chi-square test of the difference

in deviance scores ($\chi^2_{(1)}=1.34, p=0.25$). Compared to the null model, addition of the fixed effects of time increased the BIC and AIC and indicated worse fit.

Random Effects of Time. The next stage involved allowing the effect (slope) of time on admission rates to vary across counties. The equation for this model was

$$\text{Admission Rate} = \beta_{00} + \beta_{10}(\text{time}) + r_0 + r_1(\text{time}) + e$$

with parameter estimates and standard errors presented in Table 5. The coefficient for time was still not significant and indicated the fixed effect of time did not affect admission rates. Despite a non-significant coefficient, the random effect of time was accounted for a relatively small but significant ($r_1=387.15, p=.00$) amount of variance at the group level. This indicated that there was significant random variation in the effect of time on admission rates across counties. Figure 3 depicts the relationship between time (random slopes) and admission rate for all counties.

Table 5. Time Model (random slopes)

Fixed Effects	Coefficient	SE	p
Intercept, β_{00}	205.72	14.37	.00
Time, β_{10}	2.07	2.85	.47
Random Effects	Variance Component	SD	p
Intercept, r_0	13,008.28	114.05	.00
Time, slope, r_1	387.15	19.68	.00
Level-1 effect, e	6,621.19	81.37	

Deviance	6,504.58
AIC	6,516.58
BIC	6,542.28

Note: Level-1, $N=536$. Level-2, $N=67$. Values rounded to nearest hundredth.

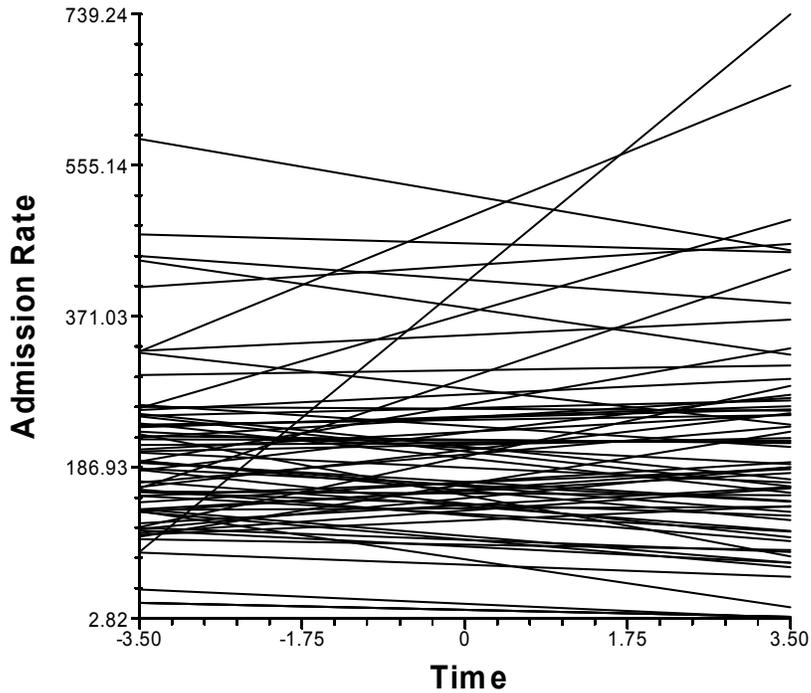


Figure 3. Random Effects of Time on County Admission Rates

Compared to the model with just the fixed effects of time, allowing time to vary randomly across counties, slightly increased county-level intercept variance ($r_0=12,717.91$ vs. 13,008.28 respectively) and decreased individual occasion variance ($r_1=8,944.10$ vs. 6,621.19). Adding the random effects of time resulted in significant improvement in model fit compared to the null model ($\chi^2_{(3)}=63.35$, $p=.00$) and the model with just the fixed effects of time only ($\chi^2_{(2)}=62.00$, $p=.00$). Improved model fit was also seen in decreased AIC and BIC values.

Final Model

Fixed Effects of Explanatory Variables. In order to explain the variance in admission rates at the occasion and county level, all Level-1 and Level-2 explanatory variables were entered and the fixed effects examined. Time was known to have significant variation across counties; therefore, the random effects of time were included in all subsequent models. The effects for quadratic and cubic trends over time were also included in the model at this stage. The equation for the final model with fixed effects of explanatory variables and random slopes for time was

$$\begin{aligned} \text{Admission Rate} = & \beta_{00} + \beta_{01} (\text{rural-urban}) + \beta_{02} (\text{HMO}) + \\ & \beta_{03} (\text{hospital}) + \beta_{04} (\text{clinic}) + \beta_{05} (\text{physician}) + \\ & \beta_{10} (\text{time}) + \beta_{20} (\text{income}) + \beta_{30} (\text{poverty}) + \\ & \beta_{40} (\text{age 0-4 years}) + \beta_{50} (\text{minority}) + \beta_{60} (\text{male}) + \\ & \beta_{70} (\text{quadratic}) + \beta_{80} (\text{cubic}) + r_0 + r_1 (\text{time}) + e \end{aligned}$$

with parameter estimates and standard errors presented in Table 6. Due to grand mean centering, the intercept is interpreted as the admission rate when all explanatory variables have the “average” value for all variables.

At this stage, the only explanatory variable with a significant coefficient was the proportion of child population 0-4 years old. As the proportion of children in that age group increased by .01 above the grand mean, the number of admissions increased by 607.62 admissions per 100,000 child population ($p=.01$). When assessed independently, variation in the effect of age on admission rates was not significant (Figure 4). No other explanatory variable had a significant coefficient.

Table 6. Final Model (random slopes for time)

Fixed Effects	Coefficient	<i>SE</i>	<i>p</i>
Intercept, β_{00}	205.72	13.78	.00
Time, β_{10}	5.58	3.88	.16
Quadratic, β_{70}	-0.17	0.94	.86
Cubic, β_{80}	-0.74	0.51	.15
Median Income, β_{20}	-0.00	0.00	.26
Child Poverty, β_{30}	77.19	127.67	.55
Age 0-4 years, β_{40}	607.62	211.63	.01
Minority Children, β_{50}	-5.08	96.56	.96
Male Children, β_{60}	-9.33	508.91	.99
Rural-Urban Level, β_{01}	-6.94	6.16	.26
HMO Enrollment, β_{02}	122.29	97.26	.21
Hospital Supply, β_{03}	-0.30	1.69	.59
Clinic Supply, β_{04}	0.45	0.55	.42
Physician Supply, β_{05}	-0.10	0.19	.60
	Variance		
Random Effects	Component	<i>SD</i>	<i>p</i>
Intercept, r_0	11,885.43	109.02	.00
Time, r_1	368.78	19.20	.00
Level-1 effect, e	6,532.65	80.83	
Deviance	6,490.19		
AIC	6,526.19		
BIC	6,603.31		

Note: Level-1, $N=536$. Level-2, $N=67$. Values rounded to nearest hundredth.

The addition of all explanatory variables slightly decreased all variance components. Compared to the model with only time (random slopes), the final model (with random slopes for time) decreased all variance components with the largest decrease at the county-level associated with the intercept ($r_0=13,008.28$ vs. 11,885.43 respectively).

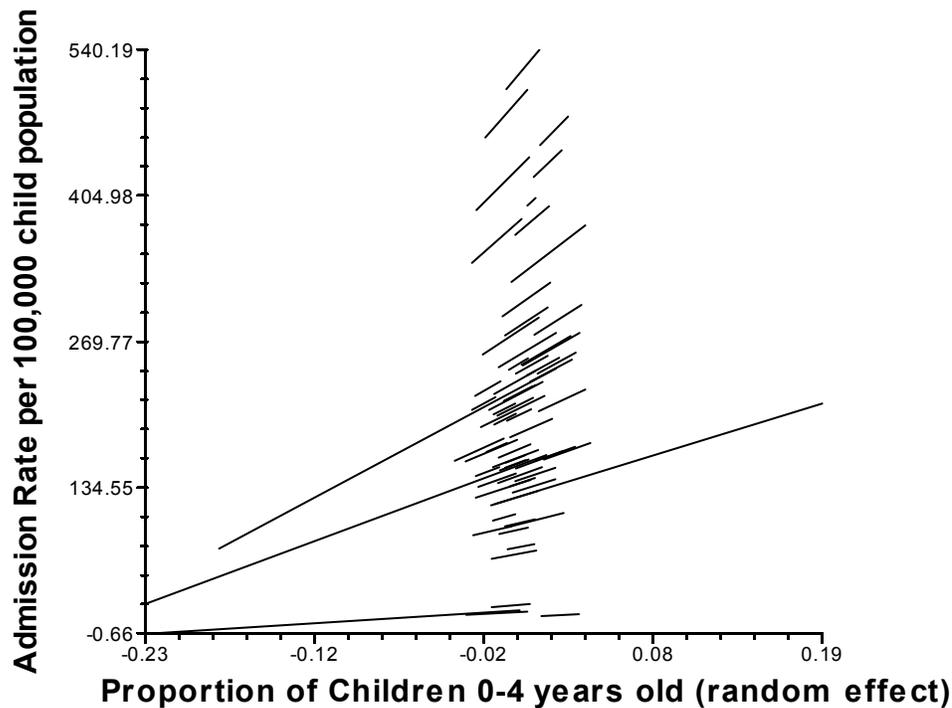


Figure 4. Random Effects of the Proportion of Children 0-4 years old on County Admission Rates

. Significant variation remained in the intercept and the effect of time across counties.

Adding the fixed effects of the explanatory variables and non-linear trends *did not* significantly improve model fit compared to the model with only time (random slopes) included ($\chi^2_{(12)}=14.39$, $p=.28$). Increased AIC and BIC values indicated worse fit.

Random Effects of Explanatory Variables. The next step involved individual assessment of the random effects of all explanatory variables and non-linear trends over time. Significant random effects were found for the proportions of minority and male children (Figures 5-6).

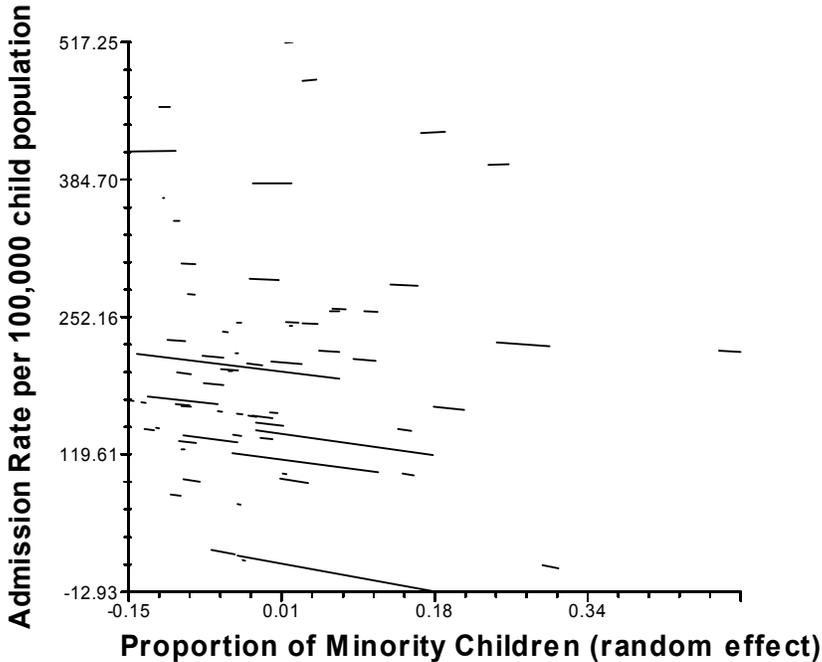


Figure 5. Random Effects of the Minority Child Proportion on County Admission Rates

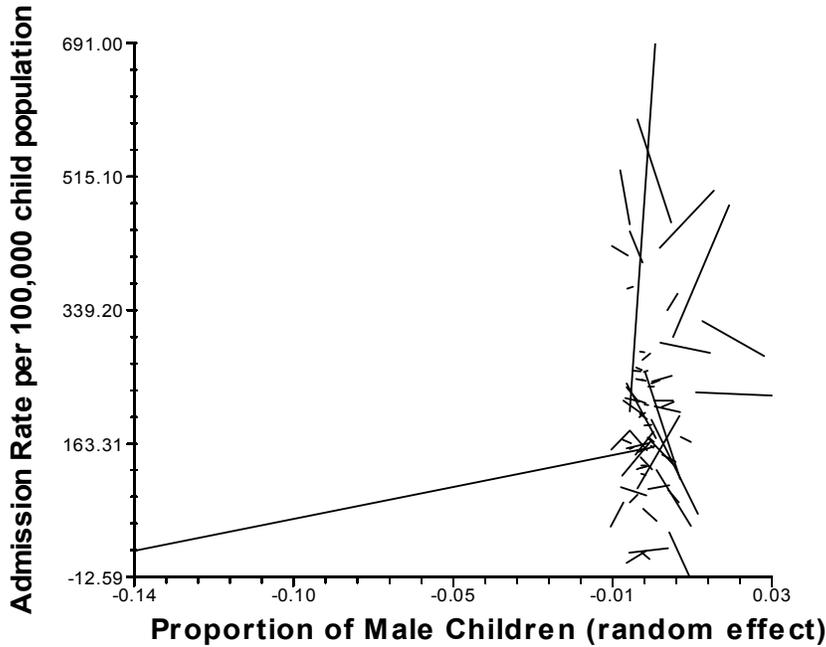


Figure 6. Random Effects of the Male Child Proportion on County Admission Rates

The relationship between admission rate and the proportion of the child population with minority race/ethnicity ranged from fairly flat to negative. The relationship between admission rate and proportion of male children ranged from positive to negative with some slopes much steeper than others.

In addition to the random effect of time, the final model included random effects associated with the proportions of minority and male children across counties. The equation for the final model was

$$\begin{aligned} \text{Admission Rate} = & \beta_{00} + \beta_{01}(\text{rural-urban}) + \beta_{02}(\text{HMO}) + \\ & \beta_{03}(\text{hospital}) + \beta_{04}(\text{clinic}) + \beta_{05}(\text{physician}) + \\ & \beta_{10}(\text{time}) + \beta_{20}(\text{income}) + \beta_{30}(\text{poverty}) + \\ & \beta_{40}(\text{age 0-4 years}) + \beta_{50}(\text{minority}) + \beta_{60}(\text{male}) + \\ & \beta_{70}(\text{quadratic}) + \beta_{80}(\text{cubic}) + r_0 + r_1(\text{time}) + \\ & r_5(\text{minority}) + r_6(\text{male}) + e \end{aligned}$$

with parameters and standard errors presented in Table 7. Even with added random effects, the proportion of children 0-4 years old remained the only significant coefficient in the model. For every .01 increase in the proportion of children aged 0-4 year old above the grand mean, gastroenteritis admissions increased by 651.60 per 100,000 child population. No other variable had a coefficient near significance. Standardized coefficients were not calculated because only one coefficient was significant,

The largest variance component was associated with proportion of male children ($r_5=435,795.50$) followed by that associated the minority children proportion ($r_6=12,597.35$). With all variables and three random effects in the model, all variance components were not

significant. There were no significant differences across counties associated with the intercept or effects of time and minority and male children on admission rates.

Table 7. Final Model (random slopes for time, minority and male)

Fixed Effects	Coefficient	SE	p
Intercept, β_{00}	205.54	13.82	.00
Time, β_{10}	5.49	3.84	.16
Quadratic, β_{70}	-0.20	0.93	.83
Cubic, β_{80}	-0.73	0.52	.16
Median Income, β_{20}	-0.00	0.00	.28
Child Poverty, β_{30}	67.33	129.98	.60
Age 0-4 years, β_{40}	651.60	194.33	.00
Minority Children, β_{50}	-25.73	87.67	.77
Male Children, β_{60}	-168.41	553.72	.76
Rural-Urban Level, β_{01}	-8.16	6.06	.18
HMO Enrollment, β_{02}	149.28	97.31	.13
Hospital Supply, β_{03}	-0.40	1.60	.80
Clinic Supply, β_{04}	0.46	0.58	.43
Physician Supply, β_{05}	-0.13	0.19	.49
	Variance		
Random Effects	Component	SD	p
Intercept, r_0	11,917.90	109.17	>.50
Time, r_1	370.39	19.25	>.50
Minority Children, r_5	12,597.35	112.24	>.50
Male Children, r_6	435,795.50	660.15	>.50
Level-1 effect, e	6,506.60	80.66	
Deviance	6,488.85		
AIC	6,538.85		
BIC	6,645.95		

Note: Level-1, $N=536$. Level-2, $N=67$. Values rounded to nearest hundredth.

Additional random effects, *did not* significantly improve model fit compared to the same model with only the random effect of time ($\chi^2_{(7)}=1.34, p>.50$). In fact, the model with

random effects (time, minority and male) did not fit the data significantly better than a model with only time and age (Table 8) ($\chi^2_{(18)}=6.56, p>.50$). The formula a model with just time, age and random slopes for time was

$$\text{Admission Rate} = \beta_{00} + \beta_{10}(\text{time}) + \beta_{40}(\text{age 0-4 years}) + r_0 + r_1(\text{time}) + e$$

with parameter estimates presented in Table 8.

Table 8. Time and Age Model (random slopes for time)

Fixed Effects	Coefficient	SE	p
Intercept, β_{00}	205.72	14.16	.00
Time, β_{10}	3.19	2.87	.27
Age 0-4 years, β_{40}	594.50	154.87	.00
Random Effects		Variance	
Random Effects	Component	SD	p
Intercept, r_0	12,622.66	112.35	.00
Time, r_1	386.03	19.65	.00
Level-1 effect, e	6,515.66	80.72	
Deviance	6,495.41		
AIC	6,509.41		
BIC	6,539.40		

Note: Level-1, N=536. Level-2, N=67. Values rounded to nearest hundredth.

Interactions

Individual assessment of all possible two-way interactions between Level-1 variables and cross-level interactions (between Level-1 and Level-2 variables) was done. The only significant interaction was the cross-level interaction of the linear effect of time and HMO enrollment. The only pattern found was that counties with the steepest positive slopes for the

effect of time on admission rates had values for HMO enrollment below the 50th percentile. No cross-level interactions between minority or male and any other Level-1 or Level-2 variables were significant.

At this step, a model with all explanatory variables, a cross-level interaction between time and HMO enrollment and random effects for time, minority and male was assessed.

The formula for this model was

$$\begin{aligned} \text{Admission Rate} = & \beta_{00} + \beta_{01}(\text{rural-urban}) + \beta_{02}(\text{HMO}) + \\ & \beta_{03}(\text{hospital}) + \beta_{04}(\text{clinic}) + \beta_{05}(\text{physician}) + \\ & \beta_{10}(\text{time}) + \beta_{20}(\text{income}) + \beta_{30}(\text{poverty}) + \\ & \beta_{40}(\text{age 0-4 years}) + \beta_{50}(\text{minority}) + \beta_{60}(\text{male}) + \\ & \beta_{70}(\text{quadratic}) + \beta_{80}(\text{cubic}) + \beta_{12}(\text{time*HMO}) + r_0 + r_1 \\ & (\text{time}) + r_5(\text{minority}) + r_6(\text{male}) + e \end{aligned}$$

with parameter estimates presented in Table 9. Coefficients for the effect of age 0-4 years and the interaction of time and HMO enrollment remained significant. No variance components were significant. AIC and BIC values were some of the highest of any model.

Transformed Variables

At this point the final model was also reassessed using transformed variables. All explanatory variables except rural-urban level had varying degrees of skew (Appendix G). Variables with positive skew were adjusted using a square root transformation. Variables with negative skew were reflected then adjusted using a square root transformation (Tabachnick & Fidell, 2001).

Table 9. Final Model with Interaction (random slopes for time, minority and male)

Fixed Effects	Coefficient	<i>SE</i>	<i>p</i>
Intercept, β_{00}	205.05	13.77	.00
Time, β_{10}	4.81	3.60	.19
Quadratic, β_{70}	-0.12	0.93	.90
Cubic, β_{80}	-.69	0.52	.18
Median Income, β_{20}	-0.00	0.00	.42
Child Poverty, β_{30}	47.98	131.24	.71
Age 0-4 years, β_{40}	632.77	196.91	.00
Minority Children, β_{50}	-25.77	87.20	.77
Male Children, β_{60}	13.17	698.97	.99
Rural-Urban Level, β_{01}	-8.00	6.03	.19
HMO Enrollment, β_{02}	95.61	95.73	.32
Hospital Supply, β_{03}	-0.13	1.58	.79
Clinic Supply, β_{04}	0.48	0.58	.41
Physician Supply, β_{05}	-0.13	0.18	.50
Time*HMO, β_{12}	-40.02	18.57	.04
Random Effects	Variance Component	<i>SD</i>	<i>p</i>
Intercept, r_0	11,783.93	108.55	>.50
Time, r_1	352.16	18.77	>.50
Minority Children, r_5	19,128.40	138.31	>.50
Male Children, r_6	1,148,576.76	1071.72	>.50
Level-1 effect, e	6,480.81	80.50	
Deviance	6,485.23		
AIC	6,537.23		
BIC	6,648.61		

Note: Level-1, $N=536$. Level-2, $N=67$. Values rounded to nearest hundredth.

Time and the proportions of minority and male children were found to have significant variance components when assessed individually. When they were in the model together, no variance components could be computed. In order to calculate variance components, the minority child proportion was kept fixed and only the proportion of male children was allowed to vary randomly because it had the larger variance component of the

two variables. The cross-level interaction between time and HMO was also significant and included in the model. Findings were essentially similar to the analysis of the untransformed variables (see Table 15 in Appendix H).

Variance Explained and Power

The final model (random slopes for time, minority and male) with an interaction decreased unexplained variance by approximately 27.7% at the individual occasion-level and 9.4% at the group-level. Table 10 provides a summary of the variance explained (R^2) and model fit. To assess power post-hoc, multiple sources were consulted. All sources indicated the study had inadequate power.

Table 10. Summary of Variance Explained and Model Fit

Model	R^2 Level- 1	R^2 Level- 2	Deviance	AIC	BIC
Null	--	--	6,567.93	6,573.93	6,586.78
Time (fixed)	--	--	6,566.59	6,574.59	6,591.72
Time (random)	--	--	6,504.58	6,516.58	6,542.28
Time and Age (time random)	27.36	0.75	6,495.41	6,509.41	6,539.40
Final (time random)	27.17	6.55	6,490.19	6,526.19	6,603.31
Final (time, minority and male random)	27.46	6.29	6,488.85	6,538.85	6,645.95
Final with Time*HMO (time, minority and male random)	27.70	9.40	6,483.23	6,537.23	6,648.61

Note: Values rounded to the nearest hundredth.

Chapter Five: Discussion

Introduction

Despite an increased focus on primary care delivery, the impact of avoidable hospitalizations on Florida children and healthcare resources was substantial. Nearly 65,000 children were admitted to the hospital for gastroenteritis during 1995-2002 resulting in about \$247.5 million in hospital charges. Every year until 2002, the largest percentage of children admitted were privately insured. The percentage of children admitted with public insurance rose each year until it surpassed the percentage of those with private coverage for the first time in 2002 (49.7% vs. 46.4%) (Table 11 in Appendix C). Increasing numbers of potentially avoidable hospitalizations of publicly insured children with gastroenteritis was accompanied by increased charges for this group. In 2002, hospital charges for publicly insured children admitted with gastroenteritis accounted for \$20.7 million or 52.1% of charges for all pediatric gastroenteritis hospitalizations.

Many studies have identifying factors associated with potentially avoidable hospitalizations in children focused on individual characteristics. This project attempted to explain variation just in pediatric gastroenteritis admissions in Florida with the understanding that children and families are embedded in communities with characteristics that may or may not facilitate access to and use of primary healthcare resources. The community of interest was the child's county of residence. Explanatory factors included the overall county socioeconomic status and level of healthcare resources, both of which can potentially affect admission rates. The next sections provide a discussion of the results as well as limitations of the study and considerations for future research. In terms of missing data, a conservative approach was used to avoid increasing the chance of type I error. In the end, none of the hypotheses were supported by the data.

*County Variation**Mean Admission Rate*

Across all occasions and counties, the average pediatric gastroenteritis admission rate was 205.7 admissions per 100,000 child population during the study period. This rate was higher than previously reported. Undoubtedly, the increase was in part due the expanded definition which also included children admitted with a primary diagnosis of dehydration accompanied by a secondary diagnosis of gastroenteritis. Mean admission rates varied significantly across counties during that period ranging from zero to 543.7 admissions per 100,000 child population.

Four counties had admission rates at or near zero; Levy, Liberty, Madison and Manatee. Generally, these were rural counties. No other consistent pattern of socioeconomic status or healthcare resources was found among these counties. It was possible that there were children living in these counties that were hospitalized for gastroenteritis, but their zip code could have been missing, suppressed or not assigned to their county of residence. Zip codes with fewer than 500 residents were suppressed to protect patient confidentiality. Zip codes that crossed counties were assigned to the county which contained the majority of the zip code. All four counties in question had some of their zip codes assigned to a neighboring county which contained a majority of the zip code.

Highlands County had the highest mean admission rate followed by Taylor, Hardee, Leon and Charlotte (543.7, 504.5, 478.3, 447.9 and 431.2 per 100,000 children respectively). These counties tended to be rural, with lower than average HMO enrollment and physician supply, but higher than average clinic and hospital supply. They also tended to be poor with lower than average median incomes and a larger than average percentage of children in poverty.

Level-1 Variables

County differences were responsible for more of the variance in hospital admission rates than differences among individual occasions. Variation in admission rates was poorly modeled by the explanatory variables as seen in the lack of significant coefficients associated with all but one variable. Independent assessment of all possible two-way interactions between Level-1 variables found none were significant.

Trends over Time. There was no significant linear change in gastroenteritis admission rates over time. Initially, admission rates varied significantly across counties over time (Figure 3). After accounting for variability in the effects of other variables (i.e., proportion of minority and male children) across counties, significant differences in the effect of time on admission rates across counties disappeared.

Independent assessment of all possible cross-level interactions found the interaction of time and HMO enrollment to be significant. The HMO enrollment proportion moderated the linear effect of time on admissions rates. The moderating effect of HMO on admission rates over time differed remained significant in the final model. The five counties with the sharpest increases in admission rates over time had values for HMO enrollment at or below the 50th percentile.

Counties with the largest increases in admission rates over time were Hamilton, Taylor, Dixie, Hernando and Walton. In these counties, incremental increases in time were associated with an additional 34.85 to 129.80 children admitted with gastroenteritis per 100,000 child population. These counties had an average of .02-.18 residents enrolled in HMO plans. In addition, these counties were generally rural, with higher than average poverty, hospital and clinic supply, but lower than average incomes and physician supply.

Admission rates did not show any significant quadratic or cubic rate of change over time. Variation associated with non-linear trends over time across counties was not significant. All interactions between non-linear trends and other Level-1 or Level-2 variables were not significant.

Children 0-4 years old. In all counties and models, as the proportion of children 0-4 years old in a county increased so did the gastroenteritis admission rate. Although some counties had greater increases in admission rates associated with incremental increases in the proportion of 0-4 year olds compared to other counties (Figure 4), differences across counties were not significant. This finding was not unexpected and was well supported by previous research. Gastroenteritis was more common in young children and the vast majority of children hospitalized for gastroenteritis were in this age group. This variable was not associated with any hypothesis and was included to control for the effect of age on admission rates.

Minority Children. The proportion of minority children had no significant effect on admission rates. Independent assessment found the proportion of minority children to have significantly different effects on admission rates across counties (Figure 5). In the presence of other variables, these differences disappeared. There was no discernable pattern of characteristics among counties with similar effects. Variability in the effect of the proportion of minority children on admission rates was not explained by interactions with Level-2 variables.

In some counties, increasing proportions of minority children was associated with fewer gastroenteritis admissions. This was not necessarily inconsistent with the literature. When multiple ACSCs were grouped together and assessed, minority children often had significantly higher admission rates (Friedman & Basu, 2001; Laditka, Laditka & Probst,

2005; Parker & Schoendorf, 2000; Shi & Lu, 2000; Shi, Samuels, Pease, Bailey & Corley, 1999), but when gastroenteritis was assessed by itself, white children had significantly higher admission rates (Parker & Schoendorf, 2000).

Male Children. The proportion of male children had no significant effect on admission rates. Independent assessment found the effect of the proportion of minority children to vary significantly across counties (Figure 6). Even though the variance component associated with the male child proportion was considerably larger compared to other variance components, in the presence of other variables differences in its effect on admission rates across counties disappeared. There was no discernable pattern of characteristics among counties with similar effects. Variability in the effect of the proportion of male children on admission rates was not explained by interactions with Level-2 variables.

Median Household Income. Median income had no significant effect on admission rates. Median incomes may have been too high to detect an effect on admission rates. The lowest median income was \$20,367. Out of 536 occasions, only 36 had median incomes less than \$25,000. Previous studies have found avoidable hospitalizations associated with incomes only up to \$25,000. For incomes greater than \$25,000, there were no effects on admission rates (Cable, 2002). There was no significant variation in the effect of median income on admission rates across counties.

Child Poverty. The proportion of children living in poverty had no significant effect on admission rates. There was no significant variation in the effect of child poverty admission rates across counties.

Level-2 Variables.

There were no significant effects on admission rates associated with Level-2 variables; rural-urban level, HMO enrollment and the supply of hospitals, clinics and physicians. Except for the moderating effect of HMO enrollment on the linear effect of time discussed earlier, Level-2 variables did not help to explain variability in the effects of Level-1 variables. Except for rural-urban level, all Level-2 variables attempted to directly address the level of healthcare resources or capacity in each county. These resource measures were treated as Level-2 variables because of multiple years of missing data for all counties. The extent to which this decision affected the findings was unknown.

In the case of HMO enrollment and hospital supply, the method for defining the measures may have not accurately represented the level of those resources. HMO enrollment was hypothesized to be negatively associated with admission rates. HMOs represented only one type of managed care program and the HMO enrollment rate was only a crude estimation of the degree of managed care. HMO enrollment included residents of all ages and may not have accurately reflected the degree of managed care penetration in children. Increased hospital or acute care capacity was expected to be positively associated with admission rates. Hospital supply defined as the number of hospital beds per 100,000 children may more accurately reflected differences in acute care capacity among counties.

Variance Explained and Model Fit

The proportion of unexplained variance at each level decreased with the addition of variables, random effects and the interaction (Table 10). The majority of variance was at the group level ($\rho=58.6\%$), but the variables did a poor job of modeling variability at Level-2. The final model (with an interaction and random slopes for time, minority and age) reduced unexplained variance across counties by 9.4% and across individual occasions by 27.7%. It

is important to note, however, that the almost the same amount of Level-1 variance can be reduced with time (random slopes) and age as the only explanatory variables. Testing the deviance values between these two models revealed that the final model with all its random effects and an interaction *did not* fit the data significantly better than one with just time (random slopes) and age ($\chi^2_{(19)}=10.18, p>.50$).

Model fit was determined by assessing the change in fit indices among two competing models. The final model (with random effects for time and age and an interaction) had poor fit with the highest BIC value (6,648.61) and the second highest AIC value (6,537.23) of any model. In comparison, the model with just time (random slopes) and age had the lowest AIC and BIC scores.

Power

Power in this multilevel design was influenced by the number of groups and the components of interest (fixed effects, cross-level interactions or variance components). Generally, a large number of groups rather than observations was suggested to achieve high power (Hox, 2002, pp173-196). With only 67 groups, this study may have had insufficient power to detect significant effects. Using software designed to calculate power in multilevel designs, power for small and medium effect sizes was estimated around .10 to .40 respectively (Liu, Spybrook, Congdon & Raudenbush, 2005). With only the largest effect sizes would there have been adequate power to detect significant differences. To increase the number of groups, future researchers may consider analysis at a lower level than county such as zip code or increasing the number of counties by including counties of neighboring states.

Limitations

Discharge Data

In addition to concerns already discussed, other limitations involved the use of administrative data in terms of quality and available data elements. Researchers using administrative data are reliant on the coding practices of individuals in terms of accurate interpretation of medical records and the completeness by data entry. Data quality can vary among individuals abstracting data from medical records within a facility and across facilities. The practice of masking zip codes leads to underestimation of gastroenteritis in counties with zip codes having fewer than 500 residents. Inability to determine a child's age in months may lead to the inappropriate inclusion of children less than 3 months old and an overestimation of admission rates.

Interpretability and Generalizability

Findings must be interpreted with care because hospital discharge data cannot account for events prior to hospitalization such as the effectiveness of care received in outpatient settings. Findings have limited generalizability areas outside of Florida and years outside the study period.

Conclusion

This project provided a benchmark for pediatric gastroenteritis admissions rates in Florida. Using AHRQ's newly revised definition makes the Florida admission rates comparable with future state and national reporting. For those involved in advocacy and healthcare policy for children, this study briefly assessed the impact of gastroenteritis admission on children's health and in terms of charges to public payers.

The limitations of this project were probably its greatest contribution to future research. Those interested in community-level studies of potentially avoidable

hospitalizations using multilevel modeling can develop more refined measures and adjust their designs to achieve adequate power. Adequately powered studies with newer measures that more accurately reflect community resources (societal and environmental) may yield different findings. Children aged 0-4 years may also be systematically different than older children. Future work may also consider comparing the effects of socioeconomic and healthcare resources on children less than five years old versus children five years and older.

Although the variables included were meaningful, they may need to be refined to detect relationships with pediatric gastroenteritis admissions at the county level of analysis. For instance, with newer data managed care penetration may be defined specifically for children and include all forms of managed care. It is also important to use a reasonable metric. It may have been beneficial to calculate admission rates and healthcare resource rates per 1,000 or 10,000 children because county child populations were often much lower than 100,000. The metric used in this project may have obscured relationships and contributed to the almost complete lack of significant results.

Newer models may consider including policy environment and family-based measures. Policy environment measures may include a county's overall political affiliation or the presence of taxes for healthcare spending. Family-based measures may include a family's willingness to use services, maternal education, health literacy and level of trust in their provider. Some family-based measures definitely pose a challenge for researchers wanting to include them in population-based analyses because the data may be difficult to incorporate at higher levels of aggregation or may not yet exist.

Clearly, younger children and their families remain the groups to target for preventive strategies. This has implications for nurses in outpatient and non-medical settings as well as researchers in terms of provider-caregiver communication. For home or outpatient

treatment to be effective, nurses must communicate successfully with caregivers. In today's busy healthcare environment, effective communication can be difficult and affected by many factors (e.g. provider cultural competency and the health literacy of caregivers). Potentially avoidable hospitalizations for gastroenteritis had a substantial impact during the study period with relatively stable rates for the entire period. This occurred despite attempts to increase the focus on primary care. It will be interesting to see if any changes have occurred in more recent years.

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Appendices

Appendix A: Inclusion Codes

ICD-9-CM diagnosis codes were used to identify children admitted with acute gastroenteritis of viral origin. Children with a principal diagnosis of gastroenteritis or dehydration plus a secondary diagnosis of dehydration were included. Gastroenteritis diagnosis codes included: enteritis (00861), enteritis adenovirus (00862), enteritis Norwalk virus (00863), enteritis other small round virus (00864), enteritis calicivirus (00865), enteritis astrovirus (00866), enteritis enterovirus necrotizing (NEC) (00867), enteritis not otherwise specified (NOS) (00869), viral enteritis NOS (0088), infectious enteritis NOS (0090), enteritis of infectious origin (0091), infectious diarrhea (0092), diarrhea of presumed infectious origin (0096), and noninfectious gastroenteritis NEC (5589). Dehydration diagnosis codes included: hypovolemia (2765, 27652) volume depletion, unspecified (27650), and dehydration (27651).

Appendix B: Exclusion Codes

Major Diagnosis Category (MDC) codes were used to exclude children with conditions related to pregnancy, childbirth and the puerperium (MDC 14) and newborns and other neonates (MDC 15). ICD-9-CM diagnosis codes were used to exclude children admitted gastrointestinal abnormalities and bacterial gastroenteritis. Child gastroenteritis discharges with any the following codes in any other diagnosis or procedure field were excluded.

Gastrointestinal abnormality diagnosis codes included: regional enteritis, small intestine (5550), regional enteritis, large intestine (5551), regional enteritis, small intestine with large intestine (5552), regional enteritis, unspecified site (5559), ulcerative chronic enterocolitis (5560), ulcerative chronic ileocolitis (5561), ulcerative chronic proctitis (5562), ulcerative chronic proctosigmoiditis (5563), pseudopolyposis of colon (5564), left-sided ulcerative chronic colitis (5565), universal ulcerative chronic colitis (5566), other ulcerative colitis (5568), ulcerative colitis NOS (5569), gastroenteritis and colitis due to radiation (5581), toxic gastroenteritis and colitis (5582), allergic gastroenteritis and colitis (5583), celiac disease (5790), tropical sprue (5791), blind loop syndrome (5792), other and unspecified postsurgical nonabsorption (5793), pancreatic steatorrhea (5794), other specified intestinal malabsorption (5798), unspecified intestinal malabsorption (5799).

Bacterial gastroenteritis diagnosis codes included: salmonella gastroenteritis (0030), shigella dysenteriae (0040), shigella flexneri (0041), shigella boydii (0042), shigella sonnei (0043), other specified shigella infections (0048), shigellosis NOS (0049), staphylococcal food poisoning (0050), botulism (0051), food poisoning due to

Appendix B (Continued)

clostridium perfringens (0052), food poisoning due to other clostridia (0053), food poisoning due to vibrio parahaemolyticus (0054), other bacterial food poisoning (0058 00589), food poisoning due to vibrio vulnificus (00581), food poisoning NOS (0059), acute amebic dysentery without mention of abscess (0060), chronic intestinal amebiasis without mention of abscess (0061), amebic nondysenteric colitis (0062), balantidiasis (0070), giardiasis (0071), coccidiosis (0072), cyclosporiasis (0075), other specified protozoal intestinal diseases (0078), unspecified protozoal intestinal disease (0079), Escherichia coli (0080), Escherichia coli NOS (00800), enteropathogenic Escherichia coli (00801), enterotoxigenic Escherichia coli (00802), enteroinvasive Escherichia coli (00803), enterohemorrhagic Escherichia coli (00804), other intestinal Escherichia coli infections (00809), Arizona group of paracolon bacilli (0081), aerobacter aerogenes (0082), proteus (0083), other specified bacteria (0084), other specified bacteria, staphylococcus (00841), other specified bacteria, pseudomonas (00842), other specified bacteria, campylobacter (00843), other specified bacteria, yersinia enterocolitica (00844), other specified bacteria, clostridium difficile (00845), other specified bacteria, other anaerobes (00846), other specified bacteria, other gram-negative bacteria (00847), other specified bacteria, other (00849), intestinal trichomoniasis (0073), cryptosporidiosis (0074), bacterial enteritis NOS (0085), and candidal enteritis (11285).

Appendix C: Table 11

Table 11. Characteristics of Pediatric Gastroenteritis Admissions by Year

Characteristic	1995	1996	1997	1998	1999	2000	2001	2002
No. of Admissions	7,965	8,192	7,738	7,873	7,711	7,916	8,612	8,065
Gender (%)								
Male	53.7	53.1	53.0	52.3	54.0	53.1	52.3	52.6
Female	46.3	46.9	47.0	47.7	46.0	46.9	47.7	47.4
Age Group (%)								
0-4 years	79.4	79.7	79.3	78.8	79.2	78.3	77.7	76.9
5-9 years	13.1	13.5	13.3	13.6	13.3	13.5	14.1	14.0
10-14 years	5.0	4.4	5.0	4.9	4.9	5.6	5.3	5.8
15-17 years	2.4	2.3	2.4	2.8	2.6	2.6	2.9	3.3
Race/Ethnicity (%)								
White	58.8	58.2	56.4	54.7	54.9	53.4	54.5	50.4
Black	20.8	21.1	21.6	21.8	18.9	18.2	16.8	17.2
Hispanic	16.4	16.0	17.4	19.1	21.0	23.5	23.5	27.0
Other*	2.8	3.5	3.0	2.7	3.7	3.5	3.8	4.3
Payer Status (%)								
Private	51.3	55.1	52.4	55.1	55.2	53.1	50.4	46.4
Public**	41.1	37.1	39.7	37.6	38.6	41.7	44.9	49.7
Uninsured†	7.6	7.8	7.8	7.3	6.2	5.3	4.6	3.9

Note: N=64,072. Values rounded to the nearest hundredth. *Includes Asian, Native American, and all other race/ethnicities. ** Includes Medicaid and all non-private third-party payers. † Includes self-pay and no charge. 1.1-1.7% of cases each year were missing race/ethnicity.

Appendix D: Table 12

Table 12. Length of Stay and Charges for Pediatric Gastroenteritis Admissions by Year

Characteristic	1995	1996	1997	1998	1999	2000	2001	2002
No. of Admissions	7,965	8,192	7,738	7,873	7,711	7,916	8,612	8,065
Mean Length of Stay (days)*	2.3	2.3	2.3	2.2	2.2	2.1	2.0	2.0
Mean Total Charges**	\$3,284	\$3,341	\$3,481	\$3,620	\$3,821	\$4,127	\$4,268	\$4,918
Aggregate Total Charges† (million)	\$26.1	\$27.4	\$26.9	\$28.5	\$29.4	\$32.7	\$36.8	\$39.7

Note: N=64,072. *Rounded to nearest tenth. **Rounded to nearest dollar. †Rounded to nearest \$100,000.

Appendix E: Table 13

Table 13. Mean Values (Standard Deviations) for County Characteristics by Year

Characteristic	1995	1996	1997	1998	1999	2000	2001	2002
Gastroenteritis Admission Rate (per 100,000 child pop.)	203.72 (160.33)	206.85 (134.17)	188.21 (188.60)	211.92 (142.27)	193.87 (125.52)	199.79 (141.85)	236.15 (177.99)	205.23 (170.47)
Proportion of Minority Children	.20 (.12)	.20 (.12)	.20 (.12)	.21 (.12)	.20 (.12)	.20 (.12)	.20 (.12)	.20 (.12)
Proportion of Children Aged 0-4 Years	.27 (.01)	.26 (.01)	.26 (.01)	.25 (.05)	.25 (.02)	.25 (.01)	.26 (.01)	.26 (.01)
Proportion of Male Children	.52 (.01)	.52 (.01)	.52 (.01)	.51 (.02)	.52 (.01)	.52 (.01)	.51 (.01)	.51 (.01)
Proportion of Children in Poverty	.25 (.07)	--	.24 (.06)	.24 (.06)	.21 (.05)	.20 (.05)	.21 (.05)	.19 (.05)
Median Household Income	\$29,306 (\$5,036)	--	\$31,033 (\$5,452)	\$32,535 (\$5,700)	\$33,560 (\$5,836)	\$35,384 (\$6,343)	\$34,570 (\$6,468)	\$34,775 (\$6,629)
Rural-Urban Level (constant added = 1)	5.15 (2.76)	5.15 (2.76)	5.15 (2.76)	5.15 (2.76)	5.15 (2.76)	5.15 (2.76)	5.15 (2.76)	5.15 (2.76)
No. of Physicians	66.09 (130.43)	--	--	--	--	81.76 (152.86)	85.52 (158.36)	--
No. of Clinics	--	--	--	--	3.16 (2.91)	3.25 (2.94)	3.43 (3.16)	--
No. of Hospitals	3.21 (4.97)	--	--	--	--	3.04 (4.63)	3.03 (4.55)	--
Proportion of HMO Enrollment (all ages)	--	--	--	--	.19 (.14)	.19 (.14)	.17 (.14)	.18 (.13)

Note: N=67 each year, no data substitution. Values are rounded to the nearest hundredth except median income is rounded to the nearest dollar. -- indicates data not available.

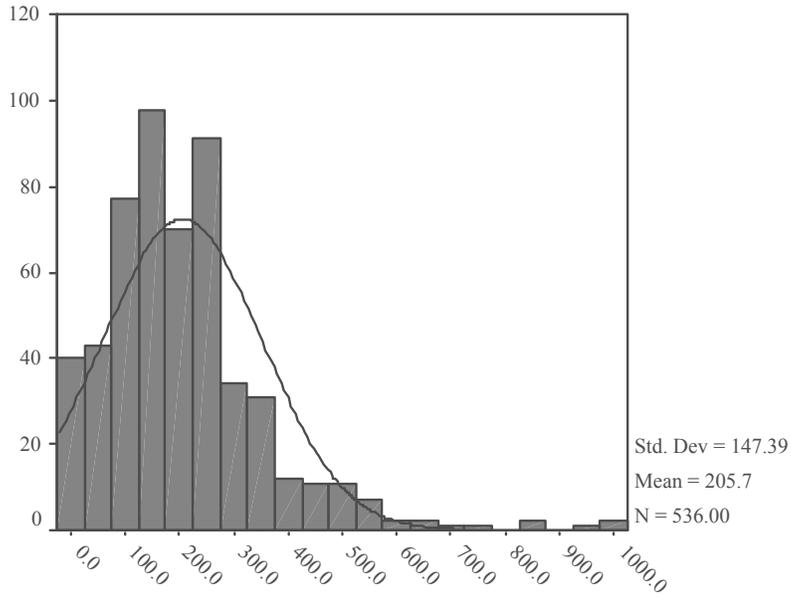
Appendix F: Table 14

Table 14. Bivariate Correlations (*r*) Among Predictor Variables

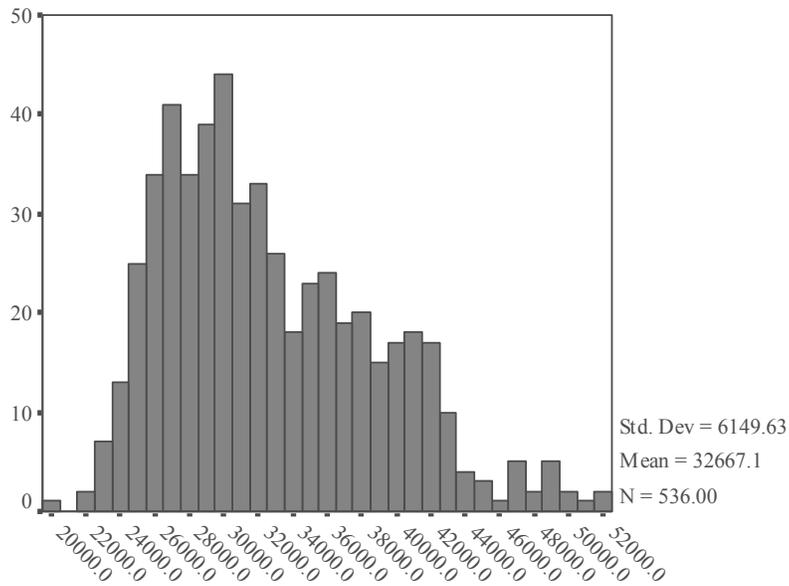
	Proportion of Minority Children	Proportion Children Aged 0-4 years	Proportion of Male Children	Proportion of Children in Poverty	Median Income	Rural-urban Level	Physician Supply	Clinic Supply	Hospital Supply	HMO Enrollment
Proportion of Minority Children		.040	-.187*	.139*	-.166*	.158*	.200*	.016	.025	.364*
Proportion Children Aged 0-4 years			.268*	.023	.040	-.054	.176*	-.146*	-.084	.125*
Proportion of Male Children				.148*	-.202*	.152*	-.191*	.299*	.066	-.184*
Proportion of Children in Poverty					-.650*	.289*	-.296*	.378*	.156*	.245*
Median Income						-.400*	.374*	-.504*	-.284*	.352*
Rural-urban Level							-.302*	.326*	.156*	-.203*
Physician Supply								-.370*	.015	.287*
Clinic Supply									.562*	-.458*
Hospital Supply										-.307*
HMO Enrollment										

Note: * indicates correlation significant at $p < .01$ (two-tailed). All rates per 100,000 child population except HMO enrollment rate was per 100,000 all age population. Average county rates for physicians, clinics, hospitals and HMO enrollment were calculated as the mean number of each resource over the mean population for the time period. Values rounded to the nearest hundredth.

Appendix G: Frequency Histograms

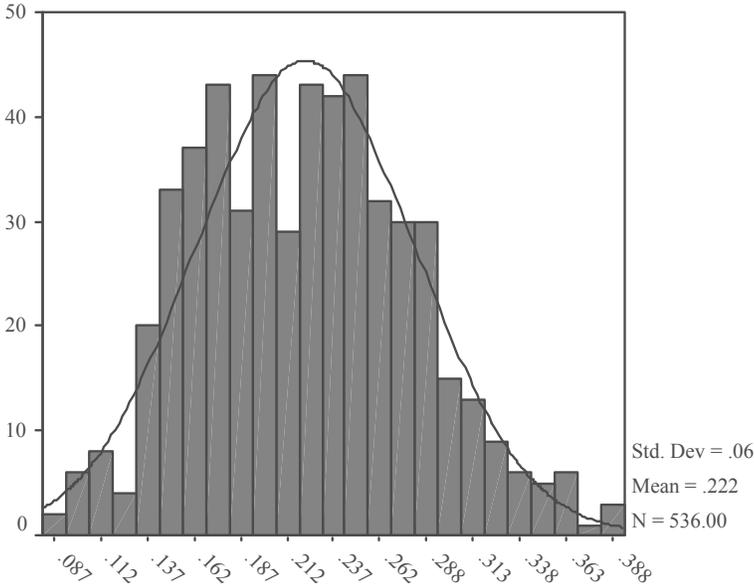


Gastroenteritis Admission Rate per 100,000 child population

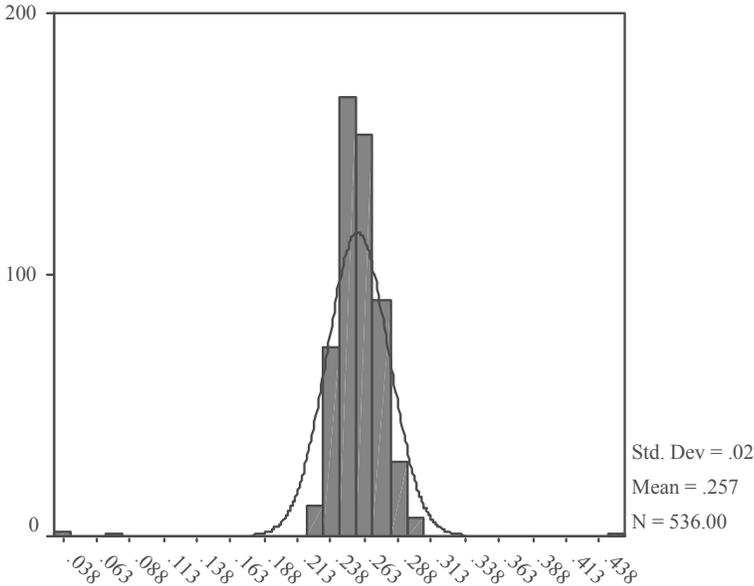


Median Income

Appendix G (Continued)

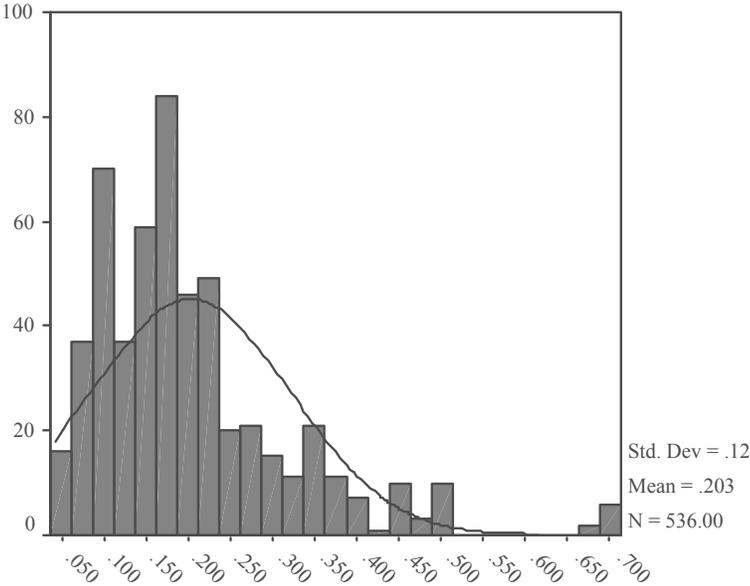


Proportion of Children in Poverty

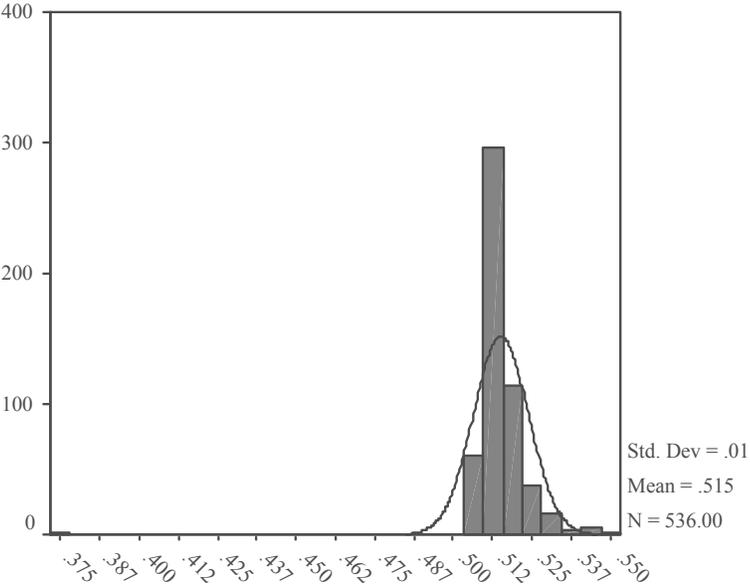


Proportion of Children Aged 0-4 years

Appendix G (Continued)

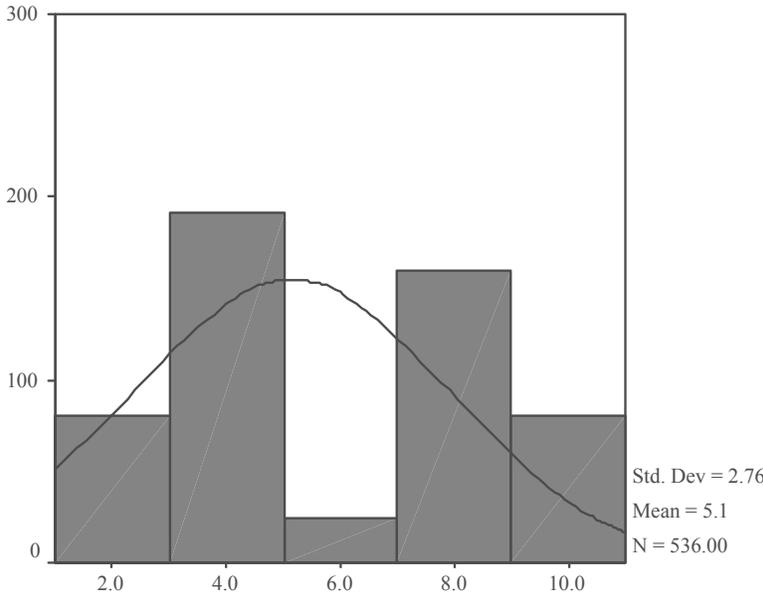


Proportion of Children with Minority Race/Ethnicity

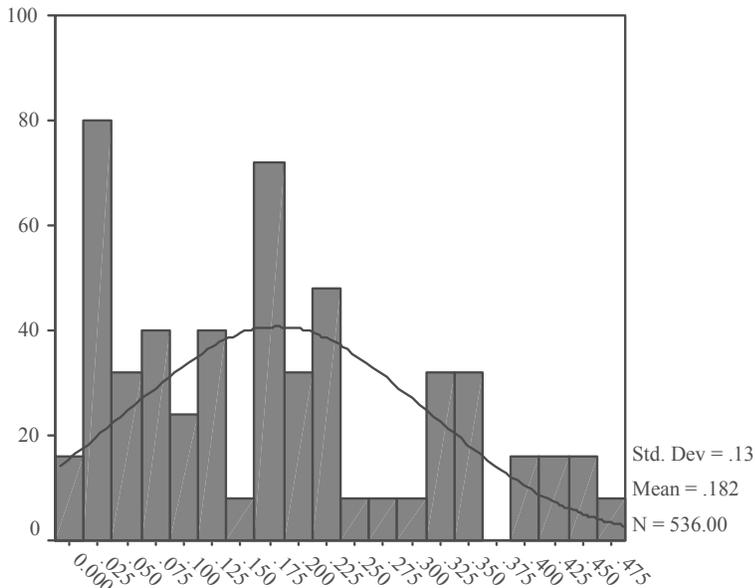


Proportion of Children with Male Gender

Appendix G (Continued)

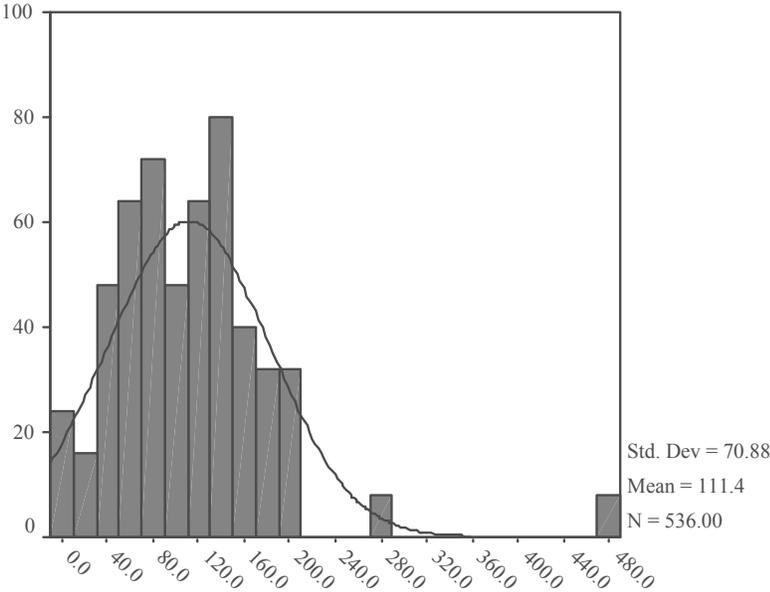


Rural-Urban Level (constant added)

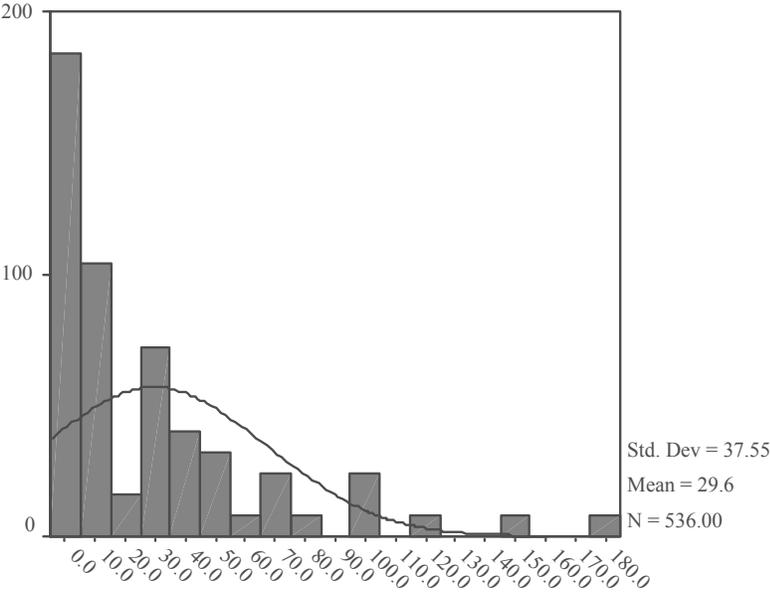


Proportion of HMO Enrollment

Appendix G (Continued)

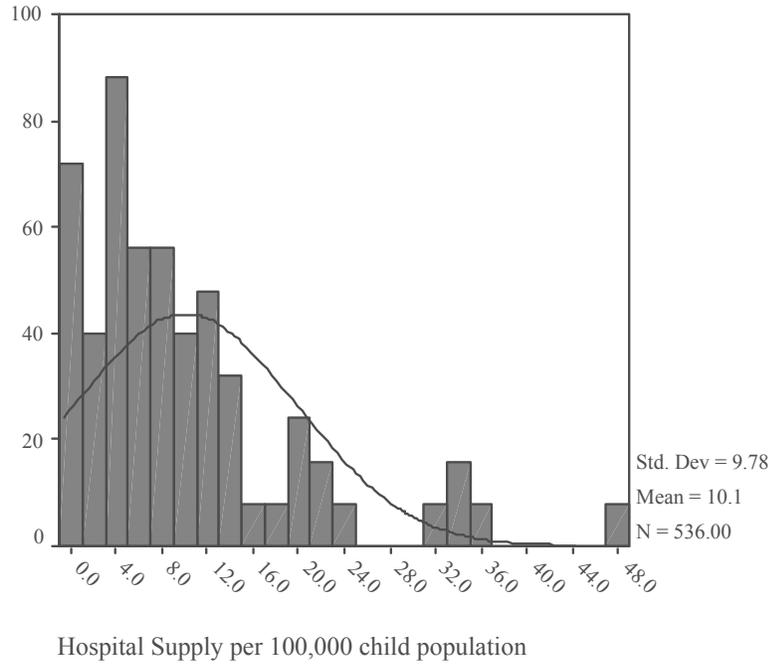


Physician Supply per 100,000 child population



Clinic Supply per 100,000 child population

Appendix G (Continued)



Appendix H: Table 15

Table 15. Full Model with Transformed Variables (random slopes for time and male.)

Fixed Effects	Coefficient	<i>SE</i>	<i>p</i>
Intercept, β_{00}	210.32	14.1	.00
Time, β_{10}	5.18	3.37	.13
Quadratic, β_{70}	.12	.93	.90
Cubic, β_{80}	-0.65	0.54	.23
Median Income, β_{20}	-.37	.57	.52
Child Poverty, β_{30}	78.56	152.68	.61
Age 0-4 years, β_{40}	-1,371.77	-2.92	.00
Minority Children, β_{50}	34.16	.32	.75
Male Children, β_{60}	-1,963.44	4,830.49	.69
Rural-Urban Level, β_{01}	-6.98	6.72	.30
HMO Enrollment, β_{02}	30.45	11.77	.70
Hospital Supply, β_{03}	1.61	11.77	.89
Clinic Supply, β_{04}	8.91	8.11	.28
Physician Supply, β_{05}	0.28	5.81	.96
	Variance		
Random Effects	Component	<i>SD</i>	<i>p</i>
Intercept, r_0	12,443.61	111.55	>.50
Time, r_1	282.05	16.79	>.50
Male Children, r_6	443,588,267.71	21,061.54	.00
Level-1 effect, e	6,380.18	79.87	
Time*HMO, β_{12}	-31.93	14.85	.04
Deviance	6,366.47		
AIC	6,408.47		
BIC	6,498.44		

Note: Level-1, $N=536$. Level-2, $N=67$. Values rounded to nearest hundredth.

All variables transformed except Rural-Urban Level. Variables with positive skew were adjusted using a square root transformation and included; median income, poverty, minority, HMO, hospital, clinic and physician. Variables with negative skew were reflected then adjusted using a square root transformation and included; age and male.

About the Author

In 1991, Jean Lee graduated cum laude after completing a Bachelor's of Science with a major in Nursing from the University of South Florida (USF). In 2002, she was accepted into the first class of the BS to PhD Program at USF's College of Nursing. While in the program, she completed a Master's of Science with a concentration in Nursing in 2004. At that time, she also received an award for academic achievement.

Jean is a registered nurse experienced in adult surgical and trauma intensive care. She has been a member of the Sigma Theta Tau International Honor Society of Nursing since 1991. She has also been a member of the American Public Health Association and Southern Nursing Research Society since 2002. In the future, she hopes to develop a career as a health services researcher.