UNIVERSITY OF KENTUCKY: THE MARTIN SCHOOL OF PUBLIC POLICY AND ADMINISTRATION

The Relationship Between Obesity and Skin and Soft Tissue Infections

Capstone Project 2010

Juliana Swiney MSPT, PharmD/MPA Candidate 2010

4/22/2010

Table of Contents

I. Executive Summary

The Problem:

It is well known that our country is experiencing an obesity epidemic: 33.9% of all adults are obese (BMI>30) and 67% of adults are either overweight or obese (BMI>25). Obesity is a risk factor for several serious disease states such as, diabetes, stroke, hypertension, heart disease and some types of cancer. It also has a less well defined relationship with skin and soft tissue infections.

Although it is known that excessive weight increases the opportunity for harmful skin conditions, this relationship has not been as well studied. Some of the mechanisms that predispose obese people to infections are known, but much of the interrelationship remains uncertain especially its impact on health care cost and policy. This study contributes to the limited knowledge on the relationship between obesity and skin and soft tissue infections.

Research Strategy and Methods:

Using the H-CUP national data base for inpatient hospitalizations, this study analyzed the data from the hospitals in several states in the South for the number of skin and soft tissue infections for the years 2003, 2005, 2007. Using the co-morbidity code for obesity, the proportion of patients who are also obese in this population was quantified for each of the three years specified. Two linear regressions analyzed the impact of obesity on the cost of health care by using length of stay and total hospital charges as dependent variables.

Major Findings:

The proportion of patients hospitalized for skin and soft tissue infections that are also obese has increased from 47.56% in 2003 to 50.42% in 2007. Surprisingly, the co-morbidity of obesity has a negative predictive value for both hospital length of stay and total hospital charges.

Recommendations for Further Studies:

This study is an initial evaluation of the relationship between obesity and skin and soft tissue infections. More research is needed to determine whether obesity is a causal factor in skin and soft tissue infections and how this is affecting the cost and delivery of health care. Local, state and federal governments are beginning to create policies aimed at addressing the obesity epidemic, but the research to support such policies is in its infancy and requires more attention to be able to inform the policy process adequately.

II. The Problem Statement

It is well known that obesity can lead to other chronic disease states including hypertension, type 2 diabetes, coronary heart disease, some cancers, hyperlipidemia and osteoarthritis.[1,2,3,4] Obesity is also known to be directly related to an increased risk of gallbladder disease, stroke, infertility, sleep apnea and musculoskeletal disease.[5,6,7,8,9]

A 2008 study found that overweight and obese people were 16% more likely to have dyslipideamia, 7% more likely to have heart disease, 14% more likely to have hypertension, and 5% more likely to have sleep apnea.[3] The obese individual has a 3.85 times greater risk of hospitalization than the non-obese person.[10] Thompson found that the risk of hypertension is about 2-fold higher and the risk for type 2 diabetes is almost 3 fold higher in the obese person.[11] Also, nearly 60% of type 2 diabetes is attributable to obesity.[12] These co-morbidities contribute to the cost and also to the mortality and morbidity of those who are overweight and obese.

The connection of obesity with skin and soft tissue disease is less well studied than with other disease states. Wolf found from the PROCEED study that people who are overweight or obese have an 8% greater prevalence of self-reported skin condition symptoms than the person who has normal weight.[3] Unfortunately, the types of skin conditions were not defined in that study.

Some of the mechanisms that predispose obese people to infections are known, but much of the interrelationship remains uncertain especially its impact on health care cost and policy. This study attempts to illuminate one small piece of this puzzle.

Using the H-CUP national data base for inpatient hospitalizations, I analyzed the data from the hospitals in several states in the South for the number of skin and soft tissue infections for the years 2003, 2005, 2007. Using the co-morbidity code for obesity, I also found the proportion of patients who are also obese in this population and track the trends for the three years specified. My hypothesis is that within the population of patients who are admitted for skin and soft tissue infections, the proportion of those who are also obese is increasing.

I have chosen to confine the research to hospitals in the South since this information is more relevant to the state of Kentucky and also because the South's rate of obesity is rising more quickly than other regions of the United States.[34] As such, if the rate of obesity within this population is increasing, this is the region in which it will most likely be found. The hospitals in the sample are a mix of large and mid-size hospitals so as to capture urban and more rural areas of the states.

A secondary outcome is the cost of obesity related skin and soft tissue infections using total hospital charges (Total Charges) and length of stay (LOS) as proxies for cost. A regression analysis was completed using length of stay and another using Total Charges as the dependent variables and age, gender of patient, median household income quartiles for patient's ZIP code, payer information, race and co-morbidity codes as independent variables.

III. Background

According to the CDC, the percent of obese adults in America (BMI>30) in 2006 was 33.9% and the percent of adults overweight (including obese) with a BMI>25 was 67%. Since the 1980-s each decade has brought an increasing prevalence of overweight and obese adults.[12,13] The latest research indicates that the prevalence of obesity seems to be stabilizing at 33.8% overall among adults and the prevalence estimates for overweight and obesity combined has stabilized at 68%.[14]

Encouragingly, the prevalence of a BMI for age at or above the 95th percentile (what is considered "obese" in children) among children and adolescents has also showed no significant changes between 1999 and 2006 except among the very heaviest 3-19 year old boys. However, it remains high at approximately 17%.[15]

This health issue touches all ethnic groups in all the states of the union and is spreading to other industrialized nations as well.[12,16] It is truly an epidemic which demands the attention of health care policy not only for its impact on individual health but also for its economic impact on the health care system.[17]

Unfortunately for Kentucky, the South is leading the country in these trends. As such, the importance of understanding the impact of obesity carries even greater significance and urgency. The cost of obesity and disease states induced by obesity is truly staggering. Currently, the cost of obesity for the country is about $147 billion and it now accounts for about 9.1% of medical spending. In Kentucky alone, the estimated direct health care costs associated with obesity in 2008 were $1.2 billion.[35] According to Wolf the mean health care costs of a person with a BMI of 20-24 (considered normal weight) was $456 ± 937 compared to a person with a BMI of >30 which was $1186 ± 2808.[3] Another study found that overall health care costs for overweight and obese people were 37% higher than for people with normal weight.[18]

In 2001, the obesity-attributable costs of health insurance to US businesses were estimated to account for 4.6% of total business spending on employee health insurance.[1] Also, it was found that mean annual medical-care costs were 36% higher over nine years for people who were obese compared to people with normal BMIs.[1] The combination of the two major determinants of obesity, lack of physical activity and excess caloric intake is now second only to smoking as the leading preventable cause of death in the United States.[19,20] Obesity is now responsible for more health care expenditures, including direct and indirect costs, than any other contributory health condition including smoking and problematic drinking.[19,20]

There are several mechanisms by which obesity increases the opportunity for harmful skin conditions. Excessive fat folds favor humidity and maceration (the breakdown of skin that is constantly kept wet) with bacterial and fungal overgrowth which can lead to severe infections requiring hospitalization for treatment. The pressure within skin folds can be sufficient in and of itself to cause skin breakdown and secondary infection.[21,22]

Obesity also impedes lymphatic flow, thus the accumulated protein-rich lymphatic fluid decreases oxygenation of the surrounding tissue leading to fibrosis and a chronic inflammatory state.[5] This state provides a hospitable culture medium for bacterial growth which can lead to serious infection. The pH of the skin is also higher in people who are obese which is more conducive for candidal superinfections since *Candida* thrives in alkaline environments.[5]

Obesity is also a risk factor for the development of chronic venous insufficiency which is a risk factor for venous ulcerations.[22] And since obesity decreases wound healing by diminishing perfusion to the injured tissue, these ulcers tend to be more severe and more difficult to treat. Increased tension on the wound edges from obesity may further aggravate wound healing or lead to dehiscence (reopening of a closed wound).[22,23]

In addition, obesity increases the incidence of several other more serious skin conditions: erysipelas (an acute streptococcal skin infection), intertrigo (inflammation of the skin folds), cellulitis (diffuse inflammation of connective tissue in the dermal and subcutaneous layers), and necrotizing fasciitis (a rapidly spreading infection of the fascia in the subcutaneous tissue due to toxins released by bacteria).[22,24,25] One study revealed that 88% of women hospitalized for necrotizing fasciitis were obese.[26]

This relationship between skin and soft tissue infections and obesity has not garnered as much attention as other disease states related to obesity, but the current research demonstrates that there is a relationship between the two. As the economic burden of obesity continues to have a significant impact on health care, this relationship may prove to be a significant portion of the overall cost. This study is a preliminary foray into the health care cost of obesity and skin and soft tissue infections.

IV. Research Strategy and Methods

The Sample

The data used for this project came from the Healthcare Cost and Utilization Project (H-CUP) Nationwide Inpatient Sample (NIS) for the years 2003, 2005, 2007. The year 2001 was originally to be used so as to give a greater spread of time to capture more data for the proposed hypotheses; however, the 2001 data set did not include the co-morbidity codes from the Disease Severity Measure files that were present in the other years. As such, I would not be able to compare the data from 2003-2007 with 2001, so this data set was not used in the analysis.

The NIS is a database of hospital inpatient stays that includes charge information on all patients regardless of payer and also includes clinical and resource use information typically available from discharge abstracts. Each year of the NIS provides information on approximately 5 million to 8 million inpatient stays from about 1,000 hospitals nationwide. The NIS is designed to approximate a 20-percent sample of U.S. community hospitals (this includes specialty hospitals, public hospitals, private hospitals, academic medical centers, acute care hospitals, but not short-term rehabilitation hospitals, long-term non-acute care hospitals, psychiatric hospitals and alcoholism/chemical dependency treatment facilities).

For this study, only the data from the following states were used: Kentucky, Georgia, North Carolina, South Carolina, Tennessee and West Virginia. These states were chosen because data for them is present in all three years and they are in the Southern region of the country. Mississippi, Alabama and Louisiana are not in the NIS database, Virginia's data for 2005 was not available and Arkansas' data for 2003 was not available. While Florida and Texas have data available for all three years, the population in each of these states is substantially different than the general population of Kentucky.

The data for this research were chosen by selecting admission diagnosis ICD-9 codes (International Statistical Classification of Diseases and Related Health Problems 9th Revision) that indicated that the admission was due to a skin or soft tissue infection for the states listed above. The following ICD-9 codes were used: 707 (chronic ulcer of skin), 680-686 (infections of skin and subcutaneous tissue) and 728.86 (necrotizing fasciitis).

Measures

The following data elements were selected for each record: age, diagnosis ICD-9 code, whether the patient died in the hospital, gender of patient, HCUP hospital number, state postal code for the hospital, length of stay (LOS), median household income quartiles for patient's ZIP code, primary payer information, race, key record identifier and total hospital charges (Total Charges).

Table 1: Data elements from H-CUP Nationwide Inpatient Sample

Age	Age in years coded 0-124 years
Female	Dummy Variable. Indicates gender 0=male, 1=female
LOS	Length of stay in number of days
Died	Dummy Variable. Indicates in-hospital heath: 0=did not die during hospitalization, 1=died during hospitalization
ZipQrtl	Median household income quartiles for patient's ZIP code. 1=$1-$38,999 2=$39,000-$47,999 3=$48,000-$62,999 4=$63,000 or more
PAY	Expected primary payer 1=Medicare, 2=Medicaid, 3=private including HMO, 4=self-pay, 5=not charge
RACE	Race, uniform coding 1=white, 2=black, 3=Hispanic, 4=Asian or pacific islander, 5= native American, 6=other
HOSPST	State postal code for the hospital (e.g. AZ for Arizona)
Cm_Arth	AHRQ co-morbidity measure: Rheumatoid arthritis/collagen vascular diseases: 0=co-morbidity is not present 1-co-morbidity is present
Cm_DM	AHRQ co-morbidity measure: diabetes uncomplicated: 0=co-morbidity is not present 1-co-morbidity
Cm_Dmcx	AHRQ co-morbidity measure: diabetes with chronic complications: 0=co-morbidity is not present 1-co-morbidity
Cm_HTN_c	AHRQ co-morbidity measure Hypertension (combine uncomplicated and complicated): 0=co-morbidity is not present 1-co-morbidity
Cm_Obese	AHRQ co-morbidity measure: Obesity: 0=co-morbidity is not present 1-co-morbidity

This selected data from the core files was then matched with data from the Disease Severity Measure files for the following co-morbidity data elements: rheumatoid arthritis/collagen vascular disease, diabetes, diabetes with chronic complications, hypertension, and obesity. These co-morbidity data elements were chosen because of their established relationship with obesity. The program used to analyze the data was STATA 11.

Procedures/ Statistical Tests

The percentage of admissions for a diagnosis of skin and soft tissue infection that were also coded as having the co-morbidity of obesity was calculated for each of the three years and a Chi- Square (χ^2) test was completed to determine if a statistically significant difference existed among the three years.

Two linear regressions were conducted with Length of Stay and Total Charges as the dependent variables. A multi-collinearity check was done in order to make sure there was no significant association or correlation among the variables for each regression. Several iterations of the regression were run in order to find the significant variables that explained each of the dependent variables, LOS and Total Charges.

The first LOS model was expressed as:

$$LOS= f(age\beta_1 + female\beta_2 + Medicare\beta_3 + Medicaid\beta_4 + PrivatePay\beta_5 + SelfPay\beta_6 + NoCharge\beta_7 + White\beta_8 + Black\beta_9 + Hispanic\beta_{10} + AsianorPacific\beta_{11} + NativeAmerican\beta_{12} + ZipQrtl1\beta_{13} + ZipQrtl2\beta_{14} + ZipQrtl3\beta_{15} + ZipQrtl3\beta_{16} + ZipQrtl4\beta_{17} + cm\_arth\beta_{18} + cm\_dmcx\beta_{19} + cm\_htn\_c\beta_{20} + cm\_obese\beta_{21} + \beta_0 +\varepsilon)$$

The final LOS model used for explanation of the relevant results was expressed as:

$$LOS= f(age\beta_1 + female\beta_2 + Medicare\beta_3 + Medicaid\beta_4 + Black\beta_9 + ZipQrtl1\beta_{13} + ZipQrtl4\beta_{17} + cm\_dmcx\beta_{19} + cm\_htn\_c\beta_{20} + cm\_obese\beta_{21} +\beta_0 + \varepsilon)$$

A similar first model was expressed for Total Charges as the dependent variable:

$$Total\ Charges= f(age\beta_1 + female\beta_2 + Medicare\beta_3 + Medicaid\beta_4 + PrivatePay\beta_5 + SelfPay\beta_6 + NoCharge\beta_7 + White\beta_8 + Black\beta_9 + Hispanic\beta_{10} + AsianorPacific\beta_{11} + NativeAmerican\beta_{12} + ZipQrtl1\beta_{13} + ZipQrtl2\beta_{14} + ZipQrtl3\beta_{15} + ZipQrtl3\beta_{16} + ZipQrtl4\beta_{17} + cm\_arth\beta_{18} + cm\_dmcx\beta_{19} + cm\_htn\_c\beta_{20} + cm\_obese\beta_{21} + \beta_0 +\varepsilon)$$

The final Total Charges model used for explanation of the relevant results was expressed as:

$$Total\ Charges = f(age\beta_1 + female\beta_2 + Medicare\beta_3 + Medicaid\beta_4 + PrivatePay\beta_5 + SelfPay\beta_6 + White\beta_8 + Black\beta_9 + ZipQrtl1\beta_{13} + ZipQrtl4\beta_{17} + \ + cm\_dmcx\beta_{19} + cm\_htn\_c\beta_{20} + cm\_obese\beta_{21} + \beta_0 + \varepsilon)$$

Since LOS and Total Charges do not have a normal distribution, a linear regression is not the most accurate model to use. A more accurate model would use the log of the dependent variable in order to compensate for the skewed data. However, some of the data points for LOS were 0 and therefore, a log-transformation of the dependent variable was not possible.

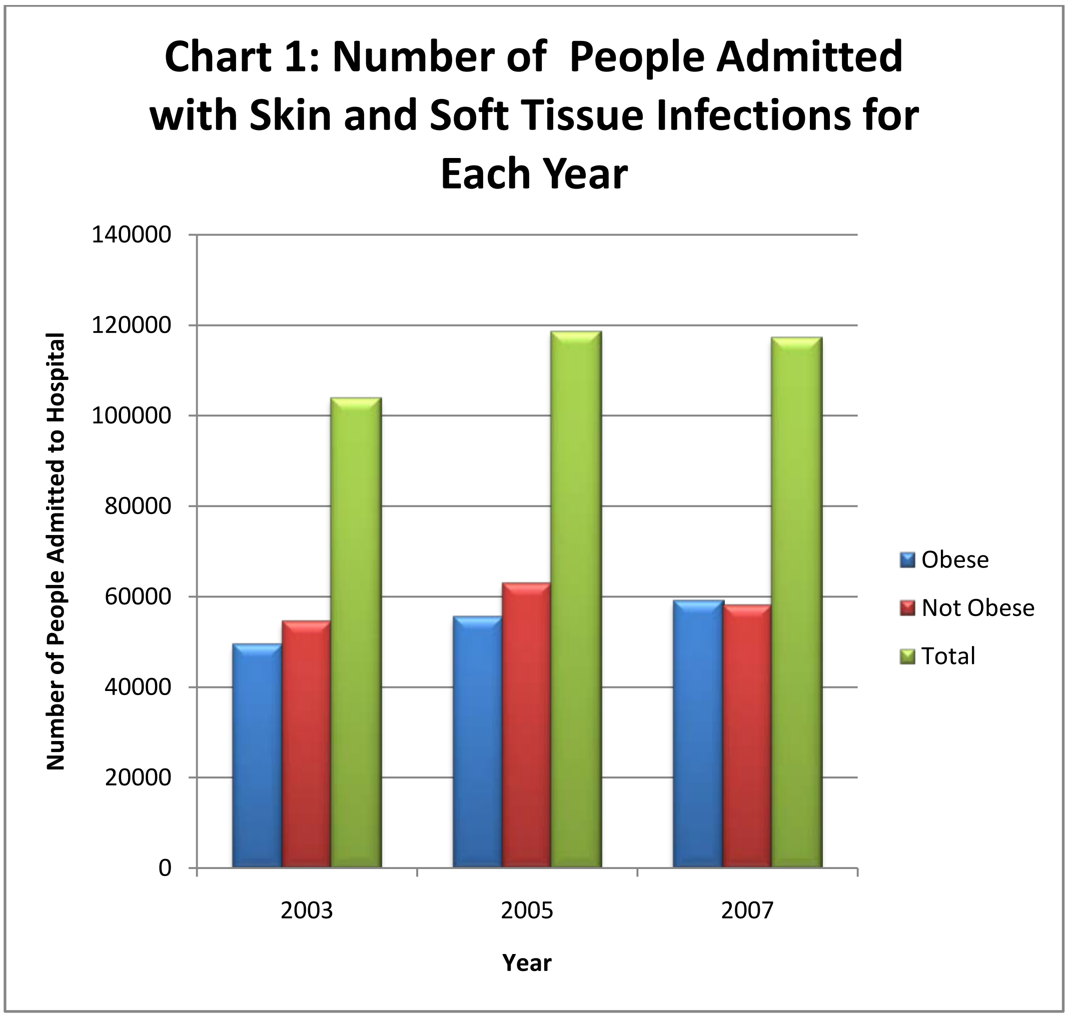
V. Results

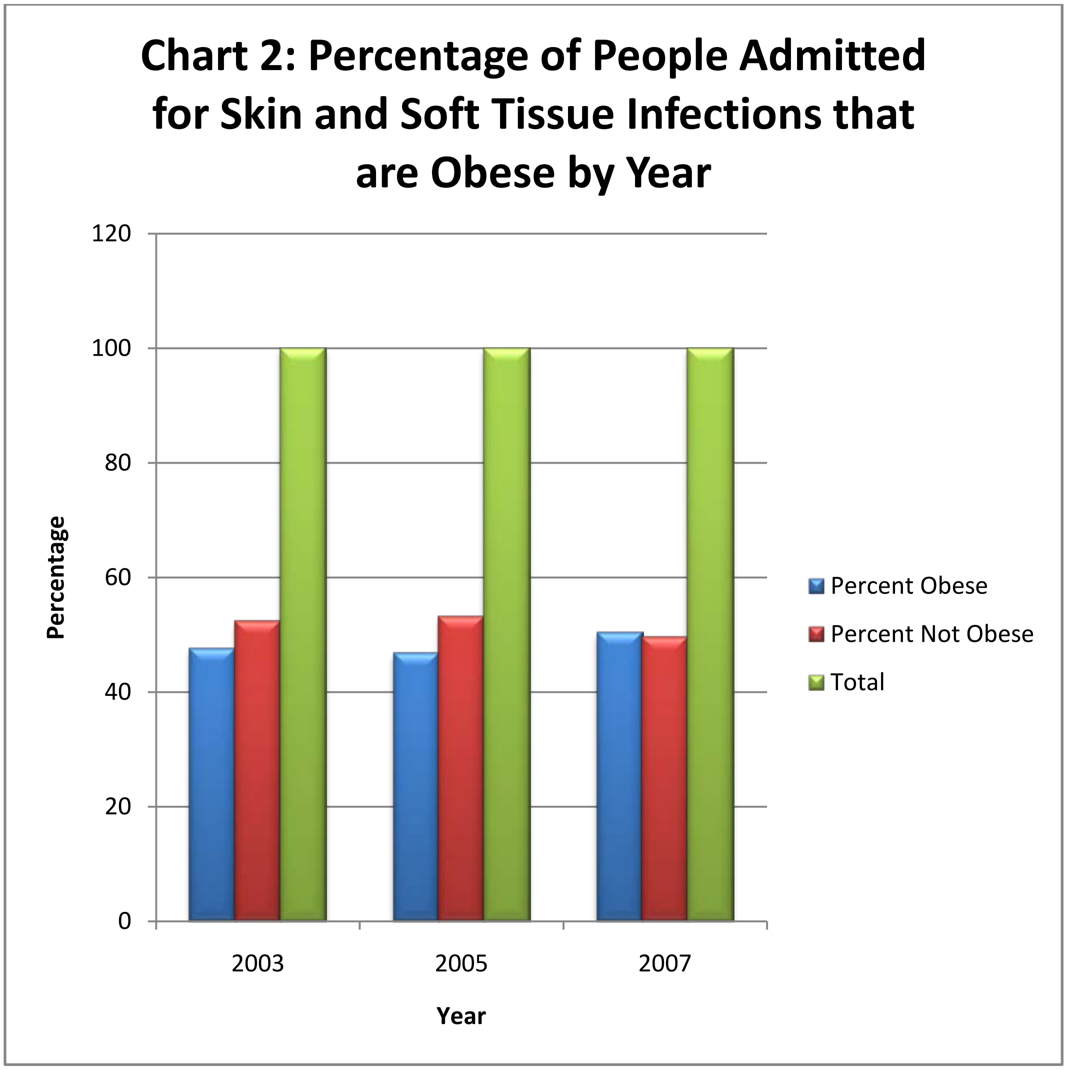
Characteristics of the sample used for this research are presented in Table 2. Each observation is one hospital admission. The number of observations for patients admitted to hospitals with skin and soft tissue infections is over 100,000 for each of the three years, thus providing a large sample size for this research project.

Table 2: Descriptive statistics for each of the three years of data (2003, 2005, 2007)

	2003	2005	2007
# of Observations	103,987	118,724	117,292
Avg. Length of Stay (days)	6.2	6.19	6.29
Avg. Total Charges (dollars)	$19,774	$23,715	$26,501
Avg. Age (years)	56.58	54.51	54.31
Male (%)	42,517 (40.89%)	48,707 (41.03%)	48,190 (41.06%)
Female (%)	61,466 (59.11%)	70,013 (58.97%)	69,134 (58.94%)
Medicare (%)	50,536 (48.77%)	54,924 (46.42%)	53,190 (45.76%)
Medicaid (%)	14,394 (13.89%)	18,839 (15.92%)	17,846 (15.35%)
Private Pay/HMO (%)	29,372 (28.25%)	32,172 (27.1%)	32,093 (27.36%)
Self Pay (%)	5,127 (4.93%)	7,978 (6.72%)	8,497 (7.24%)
White (%)	37,865 (71.05%)	35,477 (73.78%)	30,782 (70.03%)
Black (%)	14,244 (26.73%)	11,815 (24.57%)	11,800 (26.84%)
Lower Income Zip Qrtl 1 **(%)**	41,064 (40.83%)	49,746 (43.30%)	54,706 (48.19%)
Higher Income Zip Qrtl 4 **(%)**	8,611 (8.56%)	8,595 (7.48%)	9,783 (8.62%)
Co-Morbidity: Diabetes uncomplicated (%)	27,712 (26.65%)	30,141 (25.39%)	31,688 (27.02%)
Co-Morbidity: Diabetes with chronic complications (%)	7,655 (7.36%)	8,449 (7.12%)	8,908 (7.59%)
Co-Morbidity: Hypertension (%)	49,754 (47.85%)	57,284 (48.25%)	59,199 (50.47%)
Co-Morbidity: Obesity (%)	49,459 (47.56%)	55,617 (46.85%)	59,139 (50.42%)

The percent of admissions for skin and soft tissue infection that were also coded for obesity decreased for the year 2005 (46.85%) from the year 2003 (47.56%), but increases for the year 2007 (50.42%). The overall percentage of patients coded for the co-morbidity of obesity for all three years was 48.3%.





A Chi- Square (χ^2) test was performed to test the null hypothesis that there were no differences among the three years proportions of admissions that were coded as having a co-morbidity of obesity. The results from STATA are presented in Table 3.

Table 3: Chi-Squared Analysis for the proportion of people hospitalized with skin and soft tissue infections that were also coded as obese (0=not obese, 1=obese) for each year (2003, 2005, and 2007)

Key
frequency *chi2 contribution*

	YEAR			
cm_obese	2003	2005	2007	Total
0	54,528 10.9	63,107 48.4	58,153 102.2	175,788 161.5
1	49,459 11.6	55,617 51.9	59,139 109.4	164,215 172.9
Total	103,987 22.5	118,724 100.3	117,292 211.5	340,003 334.4

Pearson chi2(2) = 334.3763 Pr = 0.000

Since the computed test statistic (χ^2 =334.3763) is greater than the critical value (5.991) the null hypothesis is rejected. As such, it can be concluded that there is a statistically significant difference in the proportion of patients admitted with a co-morbidity of obesity for the three years in the data set.

A linear regression using all three years of data (2003, 2005, 2007) was used to predict Length of Stay (dependent variable). All variables that were not statistically significant were dropped and resulted in the following equation:

LOS= f(0.0342age - 0.4245female + 1.103Medicare + 1.381Medicaid + 1.257Black - 0.1657ZipQrtl1+ .104ZipQrtl4 + 0 .884cm_dmcx - 0.835 cm_htn_c - 2.65cm_obese +5.419+ ε)

Refer to Table 4 for the regression analysis using length of stay as the dependent variable.

Table 4: Linear Regression Analysis for Length of Stay as the Dependent Variable

Independent Variable	Coefficient	Standard Error	t-value	P>|t|	95% confidence interval
Age	0.034	0.0008	38.43	0.000	(0.032, 0.036)
Female	-0.424	0.0273	-15.52	0.000	(-0.478, -0.37)
Medicare	1.103	0.0352	31.31	0.000	(1.034, 1.172)
Medicaid	1.381	0.0413	33.39	0.000	(1.3, 1.462)
Black	1.257	0.0432	29.72	0.000	(1.174, 1.34)
Lower income level (ZipQrtl1)	-0.165	0.0277	-5.97	0.000	(-0.2201, -0.1113)
Higher income level (ZipQrtl4)	0.104	0.051	2.07	0.038	(0.0055, 0.2041)
Diabetes comorbidity	0.884	0.051	17.3	0.000	(0.784, 0.984)
Hypertension comorbidity	-0.835	0.028	-29.83	0.000	(-0.89, -0.78)
Obesity comorbidity	-2.654	0.027	-94.91	0.000	(-2.709, -2.599)
Constant	5.419	0.051	106.09	0.000	(5.319, 5.519)
Number of Observations	**339,968**				
F(10,339957)	**2180.08**				
Prob > F	**0.000**				
R-squared	**0.0603**				
Adjusted R-squared	**0.0602**				

In this regression model four variables (gender, lower income (zipQrtl1), co-morbidities of hypertension and obesity) predict a decrease in the length of stay while six variables (Age, Medicare, Medicaid, Black, higher income (ZipQrtl4) and co-morbidity of diabetes with complications) predict an increase the length of stay. The r-squared for this regression is 0.0603. This indicates that 6.03% of the variation in length of stay is explained by this set of independent variables. This seems low, but given the complexity of hospital length of stay and the simplicity of this model, it is acceptable.

A linear regression using all three years of data was used to predict Total Charges (dependent variable) and resulted in the following equation:

Total Charges =f (94age - 3087female - 1101Medicare - 845Medicaid - 649PrivatePay - 5355SelfPay + 1474 White + 4521Black - 2220ZipQrtl1 + 1995ZipQrtl4 + 1347cm_dmcx - 935 cm_htn_c - 4298 cm_obese + 23472 +ε)

Refer to Table 5 for the regression analysis using Total Charges as the dependent variable.

Table 5: Linear Regression Analysis for Total Charges as the Dependent Variable

Independent Variable	Coefficient	Standard Error	t-value	P>|t|	95% confidence interval
Age	94.70	4.111	23.04	0.000	(86.64, 102.76)
Female	-3087.30	125.989	-24.50	0.000	(-3334.2, -2840.36)
Medicare	-1101.44	315.492	-3.49	0.000	(-1719.8, -483.09)
Medicaid	-845.52	331.933	-2.55	0.011	(-1496.1, -194.94)
Private Pay/HMO	-649.86	311.960	-2.08	0.037	(-1261.2, -38.43)
Self Pay	-5355.96	377.717	-14.18	0.000	(-6096.2, -4615.64)
White	1474.99	136.590	10.80		(1207.2, 1742.7)
Black	4521.03	200.710	22.53	0.000	(4127.6, 4914.4)
Lower income level (ZipQrtl1)	-2220.18	128.107	-17.33	0.000	(2471.2, -1969.1)
Higher income level (ZipQrtl4)	1995.34	232.616	8.558	0.000	(1539.4, 1461.2)
Diabetes comorbidity	1347.91	235.417	5.73	0.000	(886.4, 1809.3)
Hypertension comorbidity	-935.69	128.840	-7.26	0.000	(-1188.2, -683.17)
Obesity comorbidity	-4298.25	128.778	-33.38	0.000	(-4550.6, -4045.8)
Constant	23472.34	360.869	65.04	0.000	(22765, 24179.6)
Number of Observations	**334,998**				
F(13,334984)	**363.27**				
Prob > F	**0.000**				
R-squared	**0.0139**				
Adjusted R-squared	**0.0139**				

More of the data elements were statistically significant independent variables in the regression for Total Charges than in the regression analysis for Length of Stay. Overall, eight variables have a negative predictive value for total charges (gender, Medicare, Medicaid, Private Pay/HMO, Self Pay, lower income (ZipQrtl1), co-morbidities of hypertension and obesity) and five variables have a positive predictive value for total charges (age, white, black, higher income (ZipQrtl4) and co-morbidity of diabetes with complications). All of the payer sources decrease the predicted value of total charges to varying degrees while the subcategories of race (white, black) both increase the predicted value for total charges. The r-squared for this regression model is 0.0139 indicating that 1.39% of the variation in total hospital charges is explained by the independent variables in this regression analysis. As in the Length of Stay regression, this r-squared value is low but not unexpected.

The regression analysis revealed some very interesting results for Length of Stay and for Total Charges. Most surprising is the finding that obesity has a negative predictive value for Length of Stay and for Total hospital Charges which seems counterintuitive. The hypothesis was that a co-morbidity of obesity would increase Length of Stay and Total Charges due to the added complications and poorer healing of skin and soft tissue infections in this population. However, neither regression model supports that hypothesis. For the Length of Stay regression with all other variables held constant, a co-morbidity of obesity decreases the LOS by 2.65 days. This is a statistically significant decrease with a p-value of less than 0.001. Given that the average Length of Stay is about 6.2 days a decrease of 2.65 days will definitely have an impact on hospital costs. This is seen in the Total Charges regression that with all other variables held constant, the co-morbidity of obesity decreases total hospital charges by $4,292.

Not surprisingly, increasing age will increase length of stay, most probably due to older people having more advanced disease states requiring more complicated treatments. Holding all other variables constant, every 1 year of age adds 0.03 days to length of stay and $94 to total hospital charges. Being a women decreases length of stay by almost a half a day (.424 days) and it also reduces the total hospital charges by $3,087.

Living in ZipQrt 1 (a proxy for lower income level) decreases length of stay by .165 days. This is due to the effect of income independent of Medicaid. If these people do not have Medicaid, then they stay in the hospital for a shorter period of time. But, if they have Medicaid (an income based health insurance) as the payer source, then the length of stay increases by 1.38 days. Living in a more affluent community as indicated by ZipQrt4 predicts an increase in total charges by $1,995 and an increase in length of stay by 0.104 days.

Race also impacts the length of stay. Being Caucasian does not have a statistically significant impact on the Length of Stay regression where as being black increases length of stay by one and a quarter days. However, for Total Charges, being Caucasian is statistically significant and predicts an increase in total charges by $1,474 while being Black increases total charges by $4,521 per hospital admission.

The only co-morbidity that has a positive predictive value in Length of Stay and Total Charges is diabetes (with chronic complications). For each regression the p-value is less than 0.001 for this co-morbidity. And while having chronic complications for diabetes will increase length of stay by almost a day, having hypertension decreases length of stay by almost the same amount. Both of the co-morbidities for hypertension and obesity have a negative predictive value for length of stay and total hospital charges.

Another difference between the two regressions is the payer source. While private pay/HMO and self pay were not statistically significant for Length of Stay they were both statistically significant for Total Charges (p-value 0.037 and <0.000 respectively).

There is some agreement between these two regression analyses as to what decreases length of stay and also decreases total hospital charges: female gender, lower income and co-morbidities of hypertension and obesity. Age, black race, higher income, and co-morbidity of diabetes with complications all increase length of stay and total hospital charges.

However, other variables predict opposing directions in the two models. For example, Medicare and Medicaid both increase length of stay but also, both decrease total charges. In fact, all of the payer sources decrease the predicted total charges. This can be explained by noting that the y-intercept for the Total Charges regression is $23,472. If you consider that among the payer sources, Medicaid subtracts less than Medicare from this value (-$845 vs. -$1,101), then it is reasonable to think that it subtracts less because the patients are in the hospital longer. This is supported by the Length of Stay regression where Medicaid predicts an increase in length of stay by 1.38 days vs. 1.1 days for Medicare.

VI. Discussion

The percentage of people admitted to the hospital for a skin and soft tissue infection that also have a co-morbidity of obesity changed for the three years of data. In 2003, the percentage was 47.56% and this dropped slightly to 46.85% in 2005 but then rose to 50.42% in 2007. As the χ^2 test indicates, this is a statistically significant difference in the proportions. So, while the obesity prevalence has not measurably increased in the past few years nationally, the obesity prevalence in patients admitted with skin and soft tissue infections has increased for this population. This would seem to indicate that obesity is continuing to play a greater role in patients who have skin and soft tissue infections that require admission to hospitals. And, given that about 50% of these patients are coded as having a co-morbidity of obesity, this could be an important relationship to investigate in future research.

The percentage of people who are obese in this population is greater than the national average for each of the three years and is also greater than individual state averages of 29.8% in KY, in 29.0% NC, 30.1% in SC, 30.6% in TN, 31.2% in WV for the year 2008.[12] This data suggests that among people with skin and soft tissue infections a greater percentage of them are also obese as compared to the general population. This may indicate that obesity increases the chance that a person may require hospitalization for a skin and soft tissue infection but a definitive answer to that question is beyond the scope of this research project. Further research into the causal relationship between obesity and skin and soft tissue infections would be able to address that question more fully.

Table 6: Percent of people hospitalized with skin and soft tissue infections that are also obese for each state for all three years of data combined (2003, 2005 and 2007)

	State					
Co-Morbidity of Obese	**GA**	**KY**	**NC**	**SC**	**TN**	**WV**
No	41,501	23,694	45,580	16,324	33,771	14,918
Yes	41,748	22,237	44,508	15,838	27,402	12,482
Percent Obese in each state	**50.14%**	**48.41%**	**49.4%**	**49.2%**	**44.79%**	**45.55%**

VII. Limitations

There are several limitations of this research project. Each regression analysis used a simple linear regression which is not the most appropriate regression to use since Length of Stay and Total Charges do not have a normal distribution. A more accurate model would use a log-transformation of the dependent variable. Also, only a few variables (age, gender, payer source, race, a proxy for income level and co-morbidities) were used as independent variables. There are many more variables that are involved in length of stay and in the total hospital charges that are not reflected in this data analysis.

The ICD-9 codes that were used for skin and soft tissue infections cover a broad range of types and severity of infection. For example, the ICD-9 code 682 is for “other cellulitis and abscess” and can be further specified by location but nothing in the code suggests the causal organism of the cellulitis or the severity of the infection or whether or not the patient has an abscess or has cellulitis.

Also, the proxy used for a patient's income level in this data is the median household income quartiles for the patient's zip code which introduces some inaccuracies since it is grouping the income level for the patients by the geographic area of the zip code and assigning the median income level for that whole group.

Another limitation is that this research project only used data from three years that covers a range of five years from 2003 to 2007. This may not be enough time to capture the subtleties of the changes in obesity prevalence in this population.

Lastly, the information in this data set depends on the voluntary reporting by hospitals and the ICD-9 codes are taken from patient discharge abstracts. This introduces the possibility of inconsistent reporting and coding differences by different hospitals which may have affected the results of the analysis.

VIII. Recommendations for Future Studies

This project has been an opportunity to delve into the complex relationship between obesity and skin and soft tissue infections, but it has only just begun to tease out some of the information imbued in this data set. The societal impact of obesity in relation to other disease states like diabetes or hypertension has received more research attention, but this relationship is an area ripe with research possibilities as well. This study has identified some interesting questions for future research. For example: are the types of infections that people who obese are admitted for different or more severe than the types of infections for which non-obese people are admitted? Is there a difference in the proportion of people admitted for skin and soft tissue infection who are also obese in different regions of the country? Further research into obesity and skin and soft tissue infections would be advised due to the health, economic and policy implications in our general population. As our nation struggles with the cost of healthcare and the best way in which to deliver the care, the policy implications involved in obesity are riveting.

It seems that the current laws and policies aimed at preventing or reducing obesity may be having a positive impact given that the latest data from NHANES concludes that obesity rates have leveled off nationally. I think that it is important for our society to consider how involved our government should be in our individual health choices. Since obesity is predominantly a result of greater calories consumed than expended, and eating is a necessary function for life (unlike tobacco or alcohol), how does a government try to improve the individual choices a person makes about what to eat for lunch?

In 2007, the National Cancer Institute (NCI) convened a meeting to discuss priorities for a research agenda to inform obesity policy and in 2009 this group issued a “call to action” to the research community to investigate public policy to effect structural change in order to alter population-level diet and physical activity behavior.[27,28]

There is already some public policy legislation focused on the obesity issue at the federal, state and local levels of government. The Food, Conservation and Energy Act of 2008 provides $1.3 billion in new funding over ten years for growing fruits, vegetables and nuts. It also provides vouchers for low-income seniors to purchase fruits and vegetables from local farmers and it provides about $500 million for states to provide a fresh fruit or vegetable snack in schools.[29] Kentucky enacted legislation that limits the beverages available in schools to water, 100% juice drinks, low-fat milk and beverages with no more than ten grams of sugar per serving.[30] Indiana passed a statute requiring daily physical activity in all elementary schools.[31] And, New York City's Department of Health and Mental Hygiene implemented a rule mandating that day care services offer at least sixty minutes of activity and limiting video viewing to educational programs. [32]

The most recent federal legislation, Patient Protection and Affordable Care Act, requires calorie and content be displayed next to the menu items in fast-food and chain restaurants. It also includes the formation of a National Prevention, Health Promotion and Public Health Council that has the mandate to provide recommendations to the President and Congress about changes in federal policy regarding sedentary behavior.[33] As such, the more that is known about the impact of obesity (a result of sedentary behavior) in regards to health, the better informed such policies may be.

Appendix I: Tables

Table 7: Number of observations for each state for all three years combined

Hospital State	Number of Observations	Percentage of Observations
GA	83,249	24.48%
KY	45,931	13.51%
NC	90,088	26.50%
SC	32,162	9.46%
TN	61,173	17.99%
WV	27,400	8.06%
Total	340,003	100%

Bibliography

1. Thompson D, Wolf AM. The medical-care cost burden of obesity. *Obesity Reviews* 2001;2:189-197
2. Wolf AM. Economic outcomes of the obese patient. *Obesity Research* 2002;10(1):58S-62S.
3. Wolf AM. PROCEED: prospective obesity cohort of economic evaluation and determinants: baseline health and healthcare utilization of the US sample. *Diabetes, Obesity and Metabolism* 2008;10:1248-1260.
4. Mokdad AH, Ford ES, Bowman BA et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 2003;289(1):76-79.
5. Yosipovitch G et al. Obesity and the skin: skin physiology and skin manifestations of obesity. *J Am Acad Dermatol* 2007;56(6):901-916.
6. Patterson RE et al. A comprehensive examination of health conditions associated with obesity in older adults. *Am J Prev Med* 2004;27(5):385-390.
7. Peytremann-Bridevaux I, Santos-Eggimann B. Health correlates of overweight and obesity in adults aged 50 years and over: results from the survey of health, ageing and retirement in Europe (SHARE). *Swiss Med Weekly* 2008;138(17-18):261-266.
8. Van Wayenburg CA. Encounters for common illnesses in general practice increased in obese patients. *Family Practice* 2008;Oct7:i93-i98.
9. Kress AM et al. Burden of disease associated with overweight and obesity among US military retirees and their dependents aged 38-64 2003. *Prev Med* 2005;41(1):63-69.
10. Raebel MA et al. Health services use and health care costs of obese and nonobese individuals*.* *Arch Intern Med* 2004;164:2135-2140.
11. Thompson D. et al. Lifetime health and economic consequences of obesity. *Arch Intern Med* 1999;159:2178-2183.
12. National Center of Health Statistics. Obesity among adults in the United States—no statistically significant changes since 2003-2004. Centers for Disease Control and Prevention, Nov 2007. Available at http://www.cdc.gov/nchs/data/databriefs/db01.pdf. Accessed Feb 2010.
13. The Surgeon General's call to action to prevent and decrease overweight and obesity. Rockville, MD; Office of the Surgeon General, 2001. http://www.surgeongeneral.gov/topics/obesity/calltoaction/CalltoAction.pdf. Accessed Dec 2009.

14. Flegal KM et al. Prevalence and trends in obesity among US adults, 1999-2008. *JAMA* 2010;303(3):235-241.
15. Ogden CL. Prevalence of high body mass index in US children and adolescents, 2007-2008. *JAMA* 2010;303(3):242-249.
16. World Health Organization. Obesity and overweight. Fact sheet No311 Sept. 2006. Available at http://www.who.int/mediacentre/factsheets/fs311/en/index.html Accessed Nov 2009.
17. Mello MM et al. Obesity—The new frontier of public health law. *NEJM* 2006;354(24);2601-2610.
18. Runge FC. Economic consequences of the obese. *Diabetes* 2007;56:2668-2672.
19. Smith AM et al. Action on obesity: report of a mayo clinic national summit. *Mayo Clin Proc* 2005;80(4):527-532.
20. Sturm R. The effects of obesity, smoking and drinking on medical problems and costs. *Health Affairs* 2002;21(2):245-253.
21. Gallagher Susan. The challenges of obesity and skin integrity. *Nurs Clin N Am* 2005;40:325-335.
22. Hidalgo, LG. Dermatological complications of Obesity. *Am J Clin Dermatol* 2002;3(7):407-502.
23. Meekes JR. et al. causes, investigation and treatment of leg ulceration. *British Journal of Dermatology* 203;148:388-401.
24. Oncul O. et al. Necrotizing fasciitis: a life-threatening clinical disorder in uncontrolled type 2 diabetic patients. *Diabetes Research and Clinical Practice* 2008;80:218-223.
25. Thorsteinsdottir, B et al. Abdominal wall cellulitis in the morbidly obese. *Scandinavian Journal of Infectious Diseases* 2005;37:605-608.
26. Gallup DG et al. Necrotizing fasciitis in gynecologic and obstetric patients: a surgical emergency. *Am J Obstet Gynecol* 2002;187(2):305-310.
27. Dietz WH et al. Public health law and the prevention and control of obesity. *Milbank Quarterly* 2009;87(1):215-227.
28. McKinnon RA et al. Considerations for an obesity policy research agenda. *Am J Prev Med* 2009;36(4):351-357.
29. Food, Conservation, and Energy Act of 2008, Pub.L. 110-234, May 22,2008
30. KY Rev. Stat. § 158.854(1)(2)(c) (2007)
31. Ind. Code Ann § 20-26-9-2 (2006)
32. N.Y.C. Health Code §47.36 (2008)
33. Patient Protection and Affordable Care Act, H.R. 3590, 111th congress §4205 (2010).

34. U.S. Obesity Trends by State 1985-2008. Centers for Disease Control and Prevention. Available at: http://www.cdc.gov/obesity/data/trends.html Accessed April 12, 2010.
35. Direct health care costs associated with obesity: 2008. America's Health Rankings. United Health Foundation. Available at: http://www.americashealthrankings.org/2009/obesity/ECO.aspx#Top . Accessed Feb 2010.