Distributional Issues in the Analysis of Preventable Hospitalizations

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Objective. To describe patterns in ambulatory care sensitive (ACS) admissions at the zip code level based on zip code demographic and other characteristics. These patterns include trends over time, persistence within zip codes over time, and variation between and within socioeconomic strata.
Data Sources. New York State hospital discharge data 1990–1998, U.S. census data 1990, and New York State birth records 1990.
Study Design. Age- and sex-adjusted rates and volumes of ACS admissions are calculated at the zip code level. Descriptive statistics are analyzed cross-sectionally and over time. Kernel density functions are estimated across income strata. Ordinary and quantile regression techniques are used to determine the impact of socioeconomic variables on average and extreme values of the distribution of ACS admission rates.
Principal Findings. Ambulatory care sensitive admissions rates declined during the study period but in conjunction with a greater decline in overall admission rates. Thus, as a percentage of total admissions, they actually rose by 4 percent. Ambulatory care sensitive admissions are geographically concentrated and rates are highly persistent within zip codes over time. Even on a log scale ACS admissions are typically greater and exhibit more variability among low-income zip codes. Other variables positively associated with ACS admissions are total population, births to unwed mothers (a proxy for family structure), black population, Hispanic population, and the number of non-ACS admissions. Births to immigrant mothers (a proxy for immigrant population) are negatively associated with ACS admissions.
Conclusions. The concentration and persistence of ACS admissions point to a chronic, geographically limited deficiency of primary ambulatory care in the most underserved neighborhoods. Much of the difference in preventable hospitalization levels between high- and low-income areas is driven by very high volumes in the low-income areas unrelated to population density. New York data suggest that most costs from preventable hospitalizations could be saved by focusing on targeted neighborhoods. Socioeconomic and area utilization variables play a role in both average and extreme values of the rate of preventable hospitalizations at the zip code level. Since variables that affect the average volume of preventable hospitalizations can change the distribution of that volume, analysis based on averages alone may be inadequate. The findings on area demographics and non-ACS admissions point to the need to better understand social and cultural issues as well as local admitting practice patterns to encourage appropriate and efficient use of the health care delivery system.

Key Words. Preventable hospitalizations, health disparities, health care access, ambulatory care

A key component of health care access is the receipt of timely and effective primary care to manage chronic illness and to treat acute illness at an early stage before hospitalization becomes necessary. Extensive literature documents disparities in health status on the basis of income, race, and social class (Smith 1999; Syme 1998). Some of it examines disparities in health care access and the role that access plays in determining health outcomes (Einbinder and Schulman 2000; Etchason et al. 2001; Fiscella et al. 2000; Mayberry, Mili, and Ofili 2000).

An important and frequently used indicator of primary care access is the number of ambulatory care sensitive (ACS) admissions within a population (Millman 1993). Ambulatory care sensitive admissions are defined as hospital admissions for the treatment of conditions that are "preventable with access to timely and effective ambulatory care" (Billings et al. 1993), for example, improperly managed asthma and untreated ear infections. The characteristic that is common across certain disease categories and populations at risk for ACS is the failure to obtain primary care at an earlier stage of the medical episode. Thus, the rate of ACS admissions overall has become an important indicator of health system performance in the delivery of primary care.

Several studies have documented a link between ACS admission rates and area demographics at the small area (typically zip code) level (Billings et al. 1993; Billings, Anderson, and Newman 1996; Pappas et al. 1997). These and other studies have concluded that ACS admissions are more prevalent in low-income areas and in areas with higher concentrations of racial and ethnic minorities. Moreover, the relationship between ACS admissions and socioeconomic class remains (though less strongly) even among insured populations (Billings, Anderson, and Newman 1996), which suggests that barriers to ambulatory care may extend beyond affordability to areas such as transportation, inability to make child care arrangements, or lack of knowledge about how and when to engage the system with a health problem.

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Analysis of ACS admissions typically involves comparisons among socioeconomic strata or between intervention and control groups in average rates of ACS admissions, without much attention paid to the distribution of values around the average. This approach is potentially problematic in light of the way most health services utilization is distributed across the population. As research on health care expenditures has shown, averages can give an incomplete, if not misleading, picture of the health care resources that are consumed by the "typical" individual. For example, Levit et al. (2000) calculated average per capita health spending in the United States equal to $3,739. However, Berk and Monheit (2001) found that for the same year, those in the top 10 percent of the spending distribution accounted for 69 percent of total health care expenditures. In contrast, those in the bottom 50 percent accounted for only 3 percent of total health care spending. Berk and Monheit showed further that, among those with private indemnity insurance, those in the top 10 percent of the spending distribution used an average of $11,991 of health services compared to those in the bottom 50 percent of the spending distribution who used an average of only $145 of health services. Unfortunately, it is unknown whether ACS admissions are similarly distributed, particularly at the zip code level, where many studies focus.

Research on disparities in health outcomes suggests that there may be more variation in these outcomes within, rather than across, socioeconomic strata (Deaton 2002). Rates of preventable hospitalizations may follow the same pattern, but the issue has not been well studied. This has been an important gap in the literature for two reasons. The first is cost-effective allocation of resources. For example, if ACS admission rates were distributed uniformly within poor areas, then it would be sensible to target primary care interventions on the basis of area income measures. On the other hand, if ACS admission rates vary significantly among these areas, then it may be more cost-effective to target interventions only to those areas with significantly higher than average ACS admission rates. Second, a focus on high- and low-rate areas within the same socioeconomic stratum may lead to useful findings on how to bring down ACS admissions in the high rate areas.

Efforts to reduce the rate of preventable hospitalizations would also benefit from more knowledge of persistence in rates over time. Although some have studied the issue of persistence as it relates to health spending among individuals (Eichner, McClelland, and Wise 1997; Garber, MaCurdy, and McClellan 1997), there is a paucity of research on persistence in ACS admissions.[1] If high rates of preventable hospitalization persist in the same small areas for a long time, then one would conclude that there are serious and chronic problems regarding ambulatory care access in these areas and, thus, it would be obvious where to target resources. On the other hand, if areas with very high rates of preventable hospitalizations did not maintain these high rates over time, it would be less clear where or how health care planners should focus their efforts.

This paper begins to fill these gaps in the literature by analyzing cross-sectional and longitudinal databases of ACS admissions at the zip code level in New York State. The major findings of the paper focus on the distribution of ACS admissions between and within zip codes that are stratified on the basis of per capita income. It also reports on trends in ACS admission rates in New York during the 1990s and documents the level of persistence in these rates within zip codes over the same period. Finally, the paper presents new findings on variables that influence the volume of preventable hospitalizations and illustrates the use of statistical methods that may not be familiar to most health services researchers.

DATA

Following the approach used by Billings, Zeitel, Lukomnik et al. (1993), total ACS admissions are identified for 811 zip codes in New York State using data from the Statewide Planning and Research Cooperative System (SPARCS) from 1990 through 1998. Since the population at risk for various ACS admissions varies by age and sex, the data are age- and sex-adjusted using the direct method (Newman 2001). Demographic data used for this adjustment and for calculating per capita rates came from the 1990 census and population projections for noncensus years were obtained from Claritas/NPDC, a data vendor with expertise in demographic data projection. Other parts of the analysis (described later) used birth records data for 1990 provided at the zip code level by the New York Department of Health. All analysis in this paper is limited to the population younger than age 65 due to differences in health problems and access to insurance coverage between elderly and nonelderly populations.

RESEARCH METHODS

Per Capita ACS Admission Rates

First, per capita rates of ACS admissions were measured as the number of admissions per 1,000 population in each zip code. The average (per zip code)

ACS admission rate was calculated for each year from 1990 to 1998. To put the data into perspective, ACS admission rates are contrasted with the corresponding overall hospital admission rates for the same years.

Second, the persistence of ACS admission rates within zip codes over time was analyzed. Zip codes were placed into five equally sized groups (i.e., quintiles) according to their rank in terms of ACS admission rates in 1990. Then the average ACS admission rate within each group was tabulated for each year from 1991 to 1998. If ACS admission rates moved randomly within zip codes over time, they would be expected to exhibit a pattern of regression toward the mean. In other words, average rates in the upper quintiles would be expected to converge downward toward the overall mean, and average rates in the bottom quintiles would be expected to converge upward. Absence of this pattern would suggest chronic problems in the zip codes in the upper quintiles stemming from inadequate access to care, patient-level problems, or some combination of the two. Persistence was also analyzed by calculating simple correlation coefficients between the ACS admission rate in 1990 and the corresponding rates for 1991–1998. High correlations over time would indicate a large degree of persistence and low correlations would mean the opposite.

Log of Total ACS Admissions

After documenting simple trends in ACS admission rates, the analysis shifted to the distribution of ACS admission rates across zip codes in a single year. This analysis was done for 1990 only because complete data on income and all other demographic variables at the zip code level were not available for the other years.

The measurement of ACS admissions in terms of per capita rates raises some important statistical issues, particularly when the focus is on describing variation in the data. First, since zip codes vary significantly by population (Table 3), the distribution of ACS admission rates across zip codes may simply reflect the degrees of freedom available for calculating per capita rates. To address this problem, all remaining analyses were weighted by population, which avoids the problem of granting disproportionate influence to sparsely populated zip codes where per capita rates are measured with greater variability.

Second, the dispersion of ACS admissions within subgroups may vary directly with the subgroup mean. In other words, subgroups with higher mean ACS admission rates, such as low-income zip codes, may also exhibit greater dispersion around the mean. Statistically, this creates the problem of heteroskedasticity, which is fairly common in the analysis of per capita utilization rates. To address these issues, the natural logarithm of total ACS admissions for each zip code (instead of the per capita admission rate) was analyzed.[2] Variation in population sizes was accounted for through the weighting described earlier and the inclusion of population as a control variable in multivariate analysis.[3]

The distribution of ACS admissions on the log scale was analyzed using the kernel density method (Silverman 1986). A kernel density is similar to a histogram except the variable of interest is expressed on a continuous scale instead of a categorical one. This method is preferred to ordinary histogram analysis, since it avoids the need to specify a priori the width and number of data intervals, which are often arbitrary and potentially restrictive (DeNardo and Tobias 2001). The key issue is how admissions are distributed across high- and low-income zip codes. The kernel densities will suggest that ACS admissions are distributed log-normally across high-income zip codes, but very differently across low-income zip codes. These propositions are tested rigorously using the Shapiro-Wilk test for normally distributed variables (Shapiro and Wilk 1965).

Linear regression methods were used to determine how various zip code characteristics affect the distribution of ACS admissions. First, ordinary least squares (OLS) regression was used to determine how zip code characteristics affect ACS admissions on average. However, as the kernel densities will suggest, analyses based on averages alone will give an incomplete description of ACS admissions across socioeconomic strata. Therefore, coefficient estimates from the OLS regression model were contrasted with corresponding estimates from quantile regression models (Narula and Wellington 1982).

Quantile regression differs from OLS regression in the following way. In the OLS model, the slope coefficient for income would describe how the average ACS admission level varies with income, holding other variables fixed. In contrast, the corresponding slope coefficient from a quantile regression for the 90th percentile would provide an estimate of how the 90th percentile of the distribution of ACS admissions varies with income, holding other variables fixed. In general, the quantile regression approach allows the researchers to understand how independent variables affect extreme as well as nonextreme (e.g., median) values of the dependent variable. In this analysis, quantile regressions are run for the 10th, 50th (median), and 90th percentiles to demonstrate the effects of independent variables on various parts of the distribution of ACS admissions.

In light of the statistical issues raised, the dependent variable in the regression analyses is the log of ACS admissions for each zip code and each observation is weighted by total population. All continuous independent variables are also measured in logs. Therefore, slope estimates for these variables can be interpreted as elasticities.

Since the model predicts a measure of ACS admissions volume, total population was included as a control variable. More importantly, the model includes variables that measure the potential vulnerability of the population residing in each zip code. These are median family income and the numbers of black non-Hispanic residents, Hispanic residents, births to immigrant mothers (a proxy for immigrant population), and births to unwed mothers (a proxy for family structure).

The final three independent variables proxy differences in local health systems and practice patterns that may affect ACS admissions. The first is the number of non-ACS admissions in the zip code, which is associated with both local practice style and prevalence of illness. The final two are indicator variables for zip codes in New York City and for rural areas of the state where local health systems and population characteristics differ in ways that are not captured by other variables in the model.

A number of variables in the model are likely to be collinear. However, a standard rule of thumb in the presence of collinear variables is that multicollinearity is not harmful if all t-statistics in the model are greater than 2 (Kennedy 1994). Since this condition is satisfied in the OLS model (Table 4), the effects of multicollinearity are presumed to be minor.[4]

Although insurance status is also an important predictor of ACS admission rates, information about insurance coverage at the zip code level does not exist. Moreover, in New York uninsured patients who are admitted as inpatients often have services reimbursed through Medicaid. Nevertheless, the lack of insurance information creates an important caveat for this analysis.

RESULTS

Trend and Persistence in ACS Admission Rates

The average ACS rate in New York exhibits a somewhat erratic, but downward trend (Table 1). However, this trend appears to be driven by a secular decline of 13 percent in total admission rates over the study period. This stands in contrast to only a 9 percent decline for ACS admissions.

Table 1: Trends in ACS and Total Hospital Admission Rates per 1,000 Population

Year	*Total Admission Rate*[a]	*ACS Admission Rate*[a]	*Ratio of ACS to Total Admissions*
1990	105.42	13.03	0.1177
1991	105.67	13.06	0.1175
1992	103.98	13.23	0.1206
1993	102.79	13.60	0.1253
1994	100.28	13.39	0.1263
1995	99.44	12.52	0.1205
1996	96.55	12.61	0.1231
1997	93.32	12.87	0.1286
1998	92.21	11.86	0.1222

[a]Age and sex adjusted.

Table 2: Average ACS admission Rate [a] by 1990 ACS Admission Rate Quintiles, 1990–1998

1990 Quintile	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
1	5.86	6.18	6.16	6.56	6.43	6.19	6.04	6.17	6.11
2	8.86	8.93	9.21	9.24	9.34	9.02	8.73	8.58	8.56
3	11.56	11.62	11.82	11.99	11.82	11.27	11.21	11.25	10.73
4	15.00	14.64	14.74	15.19	14.69	14.11	13.88	13.91	12.96
5	23.95	23.98	24.28	25.09	24.73	22.04	23.25	24.50	20.98

[a]Age and sex adjusted.

Table 3: Zip Code Characteristics[a]

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Number of ACS admissions [b]	283.38	379.14	0.84	3,199.76
Total population	19,275.38	15,936.20	3,998.80	101,293.40
Median family income	4.29	1.65	1.06	11.20
Black non-Hispanic residents	3,167.86	8,446.70	4.00	81,759.00
Hispanic residents	2,729.98	6,726.95	9.00	41,776.00
Number of births to immigrant mothers	97.09	219.71	0.00	2,058.00
Number of births to unwed mothers	118.87	223.80	1.00	1,592.00
Number of non-ACS admissions	92.38	24.24	5.45	240.93
New York City indicator	0.20	0.40	0.00	1.00
Rural indicator	0.15	0.36	0.00	1.00

[a]811 zip codes.

[b]Age and sex adjusted.

Table 4: Coefficient Estimates Using Ordinary Least Squares and Quantile Regression[a]

Variable[b]	*OLS*[c]	*Q10*[d]	*Q50*[d]	*Q90*[d]
Total population	0.93***	1.01***	0.94***	0.83***
Median family income	– 0.23***	– 0.17*	– 0.30***	– 0.16**
Black non-Hispanic residents	0.02**	0.04**	0.03***	0.00
Hispanic residents	0.09***	0.10***	0.10***	0.10***
Number of births to immigrant mothers	– 0.09***	– 0.10***	– 0.11***	– 0.09***
Number of births to unwed mothers	0.06***	0.01	0.04*	0.10***
Number of non-ACS admissions	1.34***	1.46***	1.31***	1.29***
New York City indicator	0.16***	0.18***	0.14***	0.16***
Rural indicator	0.16***	0.12**	0.18***	0.16***
Constant	– 10.13***	– 11.73***	– 10.00***	– 8.87***
R^{2e}	0.97	0.81	0.83	0.82

[a]Dependent variable is the natural log of total ambulatory care sensitive (ACS) admisisons at the zip code level ($n = 811$).

[b]All continuous variables measured in natural logs.

[c]Ordinary least squares regression.

[d]Q10-quantile regression for 10th percentile. Q50 and Q90 defined analogously.

[e]R^2 is the pseudo R^2 for Q10, Q50, and Q90.

***Significant at the 1% level.

**Significant at the 5% level.

*Significant at the 10% level.

Therefore, ACS admissions as a percent of total admissions actually ended the period 4 percent higher in 1998 compared to 1990.

Average ACS admission rates exhibit a great deal of stability over time (Table 2). When the data are stratified by quintiles of the ACS distribution in 1990, average rates within each quintile change very little during the nine-year period. The phenomenon of regression to the mean is virtually nonexistent. In fact, the average ACS rate actually rises in some periods for zip codes in the top quintile. Overall, high-rate zip codes tend to remain that way for an extended period of time, as do low-rate zip codes.

The persistence phenomenon is also illustrated by correlations between ACS admission rates over time. The correlation between these rates in 1990 and 1998 is 0.87. Squaring the correlation coefficient shows that 76 percent of the variation in ACS admission rates across zip codes in 1998 is associated with inter-zip-code variation that had already existed in 1990. Correlation coefficients between the ACS rate in 1990 and the corresponding rate in intermediate years (1991–1997) are even higher.

It is worth noting that the high rates of ACS admissions in the top quintile were not driven by unusually high rates in sparsely populated areas. For example, in 1990 the average population in the highest ACS rate quintile is 26,209 compared to an average population of 15,936 for all zip codes in the state. As a result, these zip codes in the top 20 percent according to per capita rate of ACS admissions in 1990 accounted for 47 percent of all ACS admissions in the state that year. Moreover, these same zip codes (i.e., the top quintile in 1990) still accounted for 46 percent of total ACS admissions eight years later in 1998.[5]

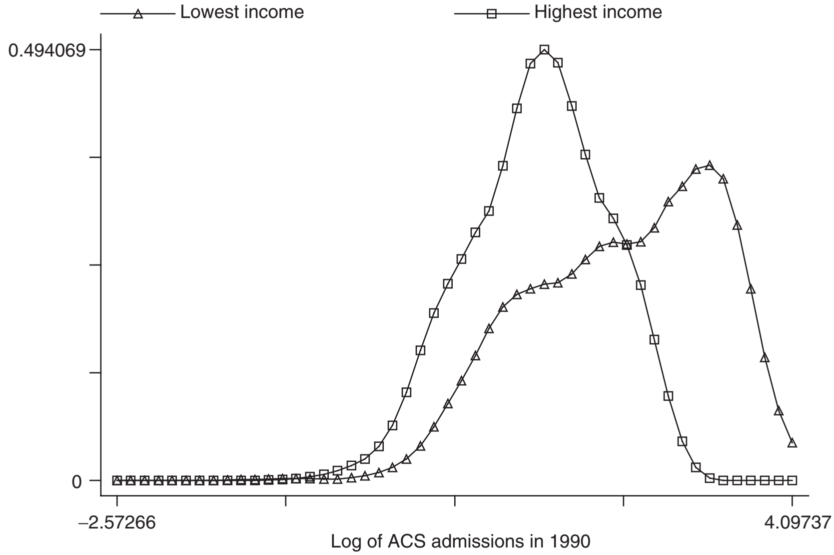
Distribution of ACS Admissions

Next the analysis focused on the distribution of ACS admissions at the zip codes level across income and other socioeconomic strata. For the reasons described, this analysis focused on the log of total admissions in each zip code weighted by population and used data from 1990 only. A t-test shows that the log of admissions is significantly higher in low-income zip codes compared to high-income zip codes (6.33 versus 5.32, $p<0.01$). Also, a Barlett's test shows that the variance in the log of admissions is also higher among low-income zip codes (1.14 versus 0.64, $p<0.01$).

Figure 1 shows kernel density estimates for ACS admissions on a log scale weighted by population. Densities are estimated separately for zip codes in the top and bottom thirds of the income distribution. In the top third, the distribution is symmetric around a single mode. The Shapiro-Wilk Test for this group could not reject the null hypothesis of normality ($Z=0.23$, $p=0.41$), suggesting that ACS admissions are distributed log-normally across high-income zip codes. The density for low-income zip codes looks quite different. The observations are more widely dispersed and asymmetrical. The Shapiro-Wilk Test in this case strongly rejects the null hypothesis of normality among low-income zip codes ($Z=4.83$, $p<0.01$).

In multivariate analysis, the OLS model shows that on average total ACS admissions move almost perfectly proportionately with total population, that is, a 10 percent increase in population is associated with a 9.3 percent increase in total ACS admissions, holding other factors fixed. However, this average effect masks the relationship between population and ACS admissions at different percentiles of the distribution of ACS admissions. In particular, the population elasticity of ACS admissions declines moving to the right of the distribution of (log) ACS admissions. This suggests that population size has less influence on ACS admissions in high-ACS volume zip codes than it does elsewhere.

Figure 1: Distribution of the Log of ACS Admissions by Area Income, 1990



As expected, the income elasticity of ACS admissions was negative. However, quantile regression showed that, holding other variables constant, income has the greatest influence in the middle of the distribution of ACS admissions.

Other variables exerted roughly the same (generally small) level of influence on ACS admissions throughout the distribution. These variables include the number of non-Hispanic black residents, the number of Hispanic residents, and the immigrant proxy variable. Interestingly, the immigrant proxy is associated with lower ACS admissions. Also, the role of race-ethnicity, particularly among blacks, is found to be quantitatively very small. These findings will be discussed in more detail.

The number of births to unwed mothers shows very different effects along different points of the distribution of ACS admissions. On average, the elasticity is small but statistically significant. However, it is totally insignificant at the 10th percentile, small but significant at the median, and much larger and significant at the 90th percentile. This suggests that the effect of unwed births (or the unobservable variables for which they proxy) on average is driven mostly by the effect on the 90th percentile, which is the area of greatest policy concern.

Like total population, the number of non-ACS admissions has its greatest influence at the low end of the distribution of ACS admissions. Although population and admitting patterns are important predictors overall, they do not exert disproportionate influence on extreme values of ACS admission volumes.

Finally, both area indicator variables were significant predictors of ACS admissions, even after controlling for other factors. The effects of both factors, however, do not vary much across the distribution of ACS admissions.

DISCUSSION

This research documents a downward trend in Ambulatory Care Sensitive (ACS) admission rates in New York State during the 1990s. At first glance, this finding suggests an increase in access to ambulatory care. Closer examination shows, however, that the downward trend is driven by a decline in all admissions, which is likely due to factors unrelated to improvements in ambulatory care access (e.g., changes in admitting practices in a changing health care delivery system). In fact, ACS admissions as a proportion of total admissions actually rose during the study period. This suggests that access to ambulatory care, particularly among low-income neighborhoods, where most ACS admissions are concentrated, has not improved and may have worsened.

This research also highlights that some neighborhoods have persistently high ACS admission rates. This finding contrasts related work on the persistence of health care expenditures among individuals. Prior research has found that high health expenditures in one period are correlated with high expenditures in the next (Eichner, McClelland, and Wise 1997; Garber, MaCurdy, and McClellan 1997). In general, however, expenditure levels for high-spending individuals tend to regress toward the mean fairly rapidly over a few years. But for preventable hospitalization rates at the zip code level, regression to the mean does not appear to take place at all.

The finding of persistence is even more striking when one considers the possibility of population mobility. If individuals move in and out of neighborhoods in a random way over time, then one would expect a rapid regression to the mean among both the top and bottom quintiles of the ACS distribution. The findings suggest that this scenario is not represented in the data. To the degree that migration exists among the chronically high-ACS neighborhoods, it is possibly biased in the sense that newcomers to the neighborhood have a higher than average susceptibility to ACS conditions. Susceptibility to these conditions may be driven by medical factors such as chronic asthma, or social factors such as difficulty complying with treatment regimens. The persistence phenomenon may also reflect the presence of environmental triggers (e.g., poor air quality), which can lead to ACS admissions, in addition to lack of ambulatory care resources. In any case, the persistence of avoidable hospitalization rates suggests the need for (and feasibility of) long-term intervention efforts that are geographically concentrated.

It is also important to note that very high ACS admission rates at the small area level cannot be dismissed as an isolated phenomenon in sparsely populated areas that have little impact on the health system as a whole. To the contrary, this research finds that nearly 50 percent of all ACS admissions in New York State are attributable to the 20 percent of neighborhoods with the greatest intensity of ACS admissions (i.e., rate per 1,000 population). It remains to be seen whether this pattern holds for other states. Nevertheless, the data from New York suggest that most of the costs associated with preventable hospitalizations could be saved by focusing on a targeted group of neighborhoods.

CONCLUSIONS

Unlike some of the policy recommendations that come from the health disparities literature, a concentrated focus on the areas with the highest ACS admission rates need not be a zero-sum game. It has been suggested elsewhere (Deaton 2002) that because the relationship between health and income is concave, income redistribution from the rich to the poor would increase the health of the poor more than it would cause a decrease in health to the wealthy. In reality, this redistribution of wealth may not be politically popular. However, in failing to avoid the costs of preventable hospitalizations, redistribution from the rich to the poor already takes place. Since ACS admissions are generally concentrated in low-income areas, these admissions tend to be reimbursed (fully or partially) through Medicaid or charity care subsidies to hospitals. These reimbursements are financed by the taxes on income and the costs of private insurance borne by higher-income people. Since these costs could be avoided by successful interventions in the highest need areas, it is possible that an effort to reduce ACS admissions in those areas could satisfy the Pareto Criterion of social welfare, which in this context would state that the health of the poor should be improved without diminishing the welfare of anyone else. The extent to which this arrangement would be a truly positive sum game depends on the costs of ACS admissions relative to the costs of effective primary care visits.

Not surprisingly, this analysis confirms the negative relationship between income and preventable hospitalizations on average. However, it goes further in providing more detail about the precise nature of this relationship. The findings show that much of the difference in preventable hospitalization levels between high- and low-income areas is driven by a greater prevalence of very high volumes in low-income areas. However, the findings also show that many low-income areas are quite comparable to high-income areas in terms of preventable hospitalization volume. Analysis of per capita rates of preventable hospitalizations and analysis with controls for population size confirm that these findings on volume of preventable admissions are not driven by differences in population densities between high- and low-income areas.

This research presents new evidence on the factors that are associated with preventable hospitalizations. Consistent with the literature on health disparities, preventable hospitalizations tend to be higher in areas with greater numbers of blacks and Hispanics. However, the quantitative impacts of these associations are found to be fairly small. It is important to note that these relationships and others in the multivariate analysis are ecological in nature and do not necessarily reflect associations that exist at the individual level. For example, the association between preventable hospitalizations and Hispanic population may be determined more by the nature of the places where Hispanics tend to live rather than greater preventable admissions among Hispanic individuals per se. Nevertheless, understanding the characteristics of zip codes with high numbers of preventable hospitalizations remains important for allocating primary care resources appropriately.

Two important findings emerge from analysis of zip code characteristics defined by birth records data. First, preventable hospitalizations tend to fall with the number of births to foreign-born mothers, which can be interpreted as a proxy for the local immigrant population overall. This result might be explained by prior research, which shows that newly arriving immigrants are generally in better than average health, and being so, are less reliant initially on the health system than native populations (Hernandez and Charney 1998). Of course, this inference should be made only tentatively in light of the potential ecological bias mentioned.

The second important finding from the birth records data concerns the number of births to unwed mothers. This variable has a small positive association with the average number of preventable hospitalizations across zip codes. More importantly, quantile regression analysis shows that this effect appears to be driven almost entirely by effects that occur at the upper tail of the distribution of preventable admissions. Specifically, the elasticity of preventable admissions with respect to this variable is 0.1 at the 90th percentile compared with 0.04 at the median and 0.01 at the 10th percentile. This is a noteworthy finding, since the upper tail of the distribution of preventable hospitalizations is the place where the greatest barriers to access, and therefore, the greatest need for policy intervention are likely to be. An important caveat is that it cannot be ascertained in this study whether preventable admissions are driven by single motherhood per se or whether this variable is serving as a proxy for other unmeasured area characteristics, such as education. Nevertheless, this finding suggests the need for more exploration of family structure and its correlates in the study of preventable hospitalizations.

In related literature, Heck and Parker (2001) report a similar finding regarding the role of family structure in determining health care access. Using self-reported subjective and objective measures of access to care for children, they found that the children of single mothers tended to have more access problems than the children of married mothers, although maternal education and Medicaid eligibility play a partially mitigating role in this relationship.

Finally, this research highlights the role of local admitting patterns in determining ACS admissions. In areas where other non-ACS admissions are high, ACS admissions may be more common because providers are more inclined to use the hospital for certain kinds of treatment even though some of these conditions may remain at a level of severity that is still ambulatory care treatable. Alternatively, in areas where non-ACS rates are low, practice variation may lead to some patients with advanced ACS conditions to forego or delay treatment. Though it is beyond the scope of this study, it is also important to recognize the potential role that reimbursement systems may play in encouraging hospital admissions over inpatient care. However, since it was not possible to control for prevalence of disease in this study, one cannot attribute the non-ACS effect solely to practice style or reimbursement incentives.

In conclusion, this research demonstrates the role played by socioeconomic and area utilization variables on both average and extreme values of the rate of preventable hospitalizations at the zip code level. In particular, variables that affect the average volume of preventable hospitalizations can change the entire distribution of that volume. Since much of the concern about preventable hospitalizations lies at the upper tail of their distribution, analysis based on averages alone may be inadequate. Moreover, if researchers are interested in simulating the impact of alternative policies on preventable hospitalizations, an understanding of distribution parameters other than the mean would add considerable precision to their analyses.

NOTES

1. An exception is a limited analysis of persistence in ACS admission rates by Billings et al. 1993.
2. To avoid taking the log of zero for variables that appear in multivariate analysis, the number 1 is added to all continuous variables before applying the log transformation.
3. Nevertheless, much of the analysis done on the log scale replicates the findings of preliminary analysis on the basis of per capita rates.
4. Although t-statistics are not displayed in Table 4, the same result is illustrated by all of the variables being significant at the 5 percent level.
5. Issues of concentration are often analyzed using the Gini coefficient. However, this measure would not provide the appropriate measure of concentration at the zip code level, since it would be driven largely by population differences across zip codes. Moreover, there is no natural way to combine the issues of persistence and concentration as done here using the Gini coefficient framework.

APPENDIX

Definition of ACS Conditions

Condition	*ICD-9-CM Codes*	*Comments*
Congenital syphilis	090	Secondary diagnosis for newborns only (age = 0 and principle diagnosis of birth [V30-V39])
Immunization preventable conditions	033, 390, 391, 037, 045, 320.0	320.0 (Ages 1-5)
Grand mal status and other epileptic convulsions	345, 780.3	
Severe ENT infections	382, 462, 463, 472.1	382 excludes otitis media cases with myringotomy with insertion of tube (20.01)
Tuberculosis	011-018	
Chronic obstructive pulmonary disease	491, 492, 494, 496, 466.0	466.0 only with secondary diagnosis of 491, 492, 494, or 496

Appendix: *Continued*

Condition	*ICD-9-CM Codes*	*Comments*
Pneumonia	481, 482.2, 482.3, 482.9, 483, 485, 486	481 excludes bacterial pneumonia cases with secondary diagnosis of sickle cell (282.6) and patients age <2 months
Asthma	493	
Congestive heart failure	428, 402.01, 402.11, 402.91, 518.4	428 excludes all congestive heart failure cases with the following surgical procedures: 36.01, 36.02, 36.05, 36.1, 37.5, 37.7
Hypertension	401.0, 401.9, 402.00, 402.10, 402.90	401.0 excludes all hypertension cases with the following surgical procedures: 36.01, 36.02, 36.05, 36.1, 37.5, 37.7
Angina	411.1, 411.8, 413	411.1 excludes all angina cases with a surgical procedure (1-86.99)
Cellulitis	681, 682, 683, 686	681 excludes cellulitis cases with a surgical procedure (1-86.99), except 86.0 (incision of skin and subcutaneous tissue), where 86.0 is the only listed surgical procedure
Skin grafts with cellulitis	DRG 263, DRG 264	Excludes admissions from skilled nursing facility or intermediate care facility
Diabetes	250.1-250.3, 250.8, 250.9, 250.0	
Hypoglycemia (unspecified)	251.2	
Gastroenteritis	558.9	
Kidney/urinary tract infection	590, 599.0, 599.9	
Dehydration/volume depletion	276.5	Examines principal and secondary diagnoses separately
Iron deficiency anemia	280.1, 280.8, 280.9	280.1 age 0–5 only and examines principal and secondary diagnoses separately
Nutritional deficiencies	260-262, 268.0, 268.1	Examines principal and secondary diagnoses separately
Failure to thrive	783.4	Age <1 only
Pelvic inflammatory disease	614	Excludes cases with a surgical procedure of hysterectomy (68.3, 68.8)
Dental conditions	521–523, 525, 528	

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