How Commonly Are Children Hospitalized for Asthma Eligible for Care in Alternative Settings?

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Objective: To estimate the proportion of children hospitalized for acute asthma exacerbation who might be cared for successfully in alternative settings such as short-stay units or in-home nursing.

Design: Descriptive study based on analysis of hospital discharge files and on retrospective medical record review of a random sample of asthma hospitalizations.

Methods: The 2028 asthma hospitalizations between 1991 and 1995 for children (aged <19 years) dwelling in Rochester, NY, were studied. Measures included the duration of frequent administration of nebulized medication (2 or more times in a 4-hour period), worst oxygen saturation levels, deterioration, and hospital length of stay. Oxygen saturation values and nebulized medication frequency were determined by hospital record review on a random sample of 443 asthma episodes. Length of stay was available for all admissions.

Results: Worst oxygen saturation following hospital admission was 95% or greater, 90% to 94%, and less than 90% for 21.3%, 51.6%, and 27.1% of episodes, respectively. Children received frequent nebulized medication treatments for a mean of 2.0 nursing shifts (8 hours per shift), although they remained hospitalized, on average, for 4.3 nursing shifts longer. Deterioration to a critical level of severity was uncommon. Among children initially admitted to the regular pediatric inpatient unit, only 0.7% subsequently deteriorated to the point that they were transferred to the critical care unit.

Conclusion: More than 70% of asthma hospitalizations in this community could be cared for in alternative settings with supplemental oxygen, nebulized medication treatments, and close nursing observation provided, in most cases, for 2 nursing shifts.


Editor’s Note: This study adds to the others, conducted in a variety of sites during the past few decades, that used different therapies and different experimental designs to show that two thirds to three quarters of children requiring more than initial emergency management of asthma can be safely and cost-effectively cared for in an observation unit with discharge in less than 24 hours.

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Estimated health care costs related to asthma totaled $6.2 billion in 1990, approximating 1% of all US health care costs. Asthma exacerbation, long the most common acute illness leading to hospitalization of children, is increasingly frequent and severe. From 1980 to 1993, the hospitalization rate due to asthma for people younger than 24 years increased 28%, and the age-specific asthma death rate more than doubled. Managed care systems increasingly pressure the practicing pediatrician to avoid hospitalization. A substantial body of evidence suggests that many hospitalizations for asthma are potentially avoidable through care in alternative settings, such as short-stay treatment and triage centers, in-home hospital-level nursing, and sick-child day care centers.

The objectives of this study were to provide estimates for (1) the proportion of asthma hospitalizations in Monroe County (Rochester), New York, that might be avoided, (2) the proportion of asthma hospital stays that might be reduced, and (3) the risk of deterioration with care in alternative settings. Estimates were derived from measures of severity that are typically obtained and services that are typically provided multiple times during the course of an acute asthma exacerbation. Because the asthma hospitalization rate for children in Rochester has been one fourth that in Boston, Mass, and half that in New Haven, Conn, avoidable asthma hospitalizations in Rochester might provide a conservative estimate for avoidable hospitalizations in many other communities.
MATERIALS AND METHODS

We conducted a descriptive study based on analysis of hospital discharge data and medical record review of a computer-generated random sample of asthma hospitalizations. The sampling frame included all 2028 hospitalizations for asthma for a 5-year period (1991-1995) for children (aged >1 month and <19 years) who were residents of Monroe County, New York.

SETTING

Detailed clinical information for characterizing illness severity and services provided over time was obtained by medical record review. In the interest of efficiency, random samples for medical record review were drawn from 2 of the 3 hospitals that care for pediatric inpatients. These 2 hospitals, a university medical center and a closely affiliated community hospital, accounted for 56.5% and 34.3% of asthma admissions, respectively, during the study period. Their emergency departments were staffed by a single group of pediatric attending and resident physicians. None of the hospitals providing pediatric inpatient care had formal criteria for admission or discharge of children with acute asthma exacerbation, nor was a formal asthma treatment protocol used in the emergency department. No limit was placed on the time a child with asthma could stay in the emergency department. Frequency of nebulized bronchodilator medication followed physician orders in both the emergency departments and inpatient units rather than judgments of respiratory therapy staff or nursing staff. Throughout the study period, most children presenting to the emergency department with acute asthma exacerbations were treated on arrival with nebulized bronchodilator medication administered almost continuously (eg, every 20 minutes) or continuously.

MEDICAL RECORD REVIEWS

The overall sampling fraction was 22% (443 medical records reviewed). Because records were also reviewed as part of a study of variation in asthma hospitalization among socioeconomic areas, sampling fractions varied by area. For the suburbs and the inner city, areas at opposite ends of the socioeconomic spectrum, sampling fraction was 26% and sampling included 181 and 192 asthma admissions, respectively. A 12% sample (70 records) was drawn from admissions of children dwelling in other urban areas. The lower sampling fraction for other urban areas was obtained because these areas were intermediate in socioeconomic status and therefore of lesser interest in the study of variation in hospitalization by socioeconomic area. It seems that undersampling of other urban areas had little effect on the representativeness of the medical record sample. As presented in the “Results” section, the medical record sample was virtually identical to all asthma hospitalizations in hospital length of stay, sex and age distributions, insurance coverage, and month of admission. Moreover, there was no difference in the proportions of asthma episodes hospitalized from the 3 socioeconomic areas that were mild, moderate, or severe. Clinical information from medical record reviews was supplemented by precise information on time of emergency department presentation and departure and on time of hospital discharge that was available in a computer database only for the university medical center.

DEFINITIONS AND MEASURES

Asthma hospitalizations were defined by a primary discharge diagnosis coded between 493.0 and 493.91 according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). Because of the critical importance of nurses as care providers for children with acute asthma exacerbation, nursing shifts, defined as any 8-hour period on an inpatient unit, were used as the primary measure of time. Periods of 4 hours or more were counted as a full nursing shift because nurses generally worked full shifts. The first 24 hours of hospitalization was defined as the entire emergency department stay plus 3 nursing shifts on an inpatient unit. Times of medication administration were used to determine “time 1” in measures of time that began with arrival on inpatient units. This convention was used because times of arrival on inpatient units were not recorded for most hospitalizations, whereas times of medication administration were almost always clearly indicated and most children admitted received nebulized medication within 4 hours of admission.

RESULTS

HOSPITALIZATION FOR ASTHMA

During the 5-year study period, 2028 hospitalizations in Monroe County were attributed to asthma and the hospitalization rate was 2.04 (95% confidence interval [CI], 1.95-2.13) per 1000 child-years. Underlying chronic disease other than asthma was present in only 1.1% of asthma hospitalizations and the proportion of hospitalizations in which children had other chronic diseases did not vary with level of severity. As reported elsewhere, rates varied substantially by age and sex. The 443 asthma exacerbations for which medical records were reviewed were very similar to all 2028 asthma hospitalizations. Mean length of hospital stay for all asthma hospitalizations was 2.52 days (95% CI, 2.45-2.60 days), compared with 2.43 days (95% CI, 2.30-2.56 days) for the medical record sample. Boys predominated among all asthma hospitalizations and in the medical record sample (64.9% and 65.0%, respectively). Children younger than 5 years predominated in both data sets (57.8% and 60.5%, respectively), and those in the first year of life represented 9.3% of admissions in both data sets. The distribution of insurance coverage included private insurance, 54.0% vs 56.9%; Medicaid, 42.8% vs 41.3%; and self-pay, 3.3% vs 1.1%. In both data sets, the 4 months in which asthma admissions were most frequent (March, September, October, and November) accounted for almost half the total (47.6% vs 49.2%).

PEAK SEVERITY

Based on unweighted analysis of worst SaO2 values obtained by medical record reviews for the 443 randomly selected episodes, mild, moderate, and severe admis-
Various measures were used to estimate potential for care in alternative settings. They included duration of frequent use of nebulized medication, hospital length of stay, hospital stay beyond the use of frequent nebulized medication, and worst arterial oxygen saturation (SaO2). Frequent use of nebulized medication was defined as nebulized medication administration on 2 or more occasions within a 4-hour period. Definition of this measure reflects the common practice in this community of instructing families that they should contact their primary care practice should they perceive a need for more than 1 treatment with nebulized medication in a 4-hour period. Also of note, this schedule for bronchodilator treatment has been used as a criterion for discharge to family home care from an emergency department extended observation unit.10 Time to last period with frequent nebulized medication was defined as the time from first nebulized medication administration until the last 4-hour period with frequent nebulized medication. Hospital stay beyond end of frequent nebulized medication included the time from the end of frequent nebulized medication until noon on the day of discharge. Noon was used as the time for all discharges because exact discharge times often were not indicated and most discharges occur around that time. Hospital length of stay was defined as the time from the first nebulized medication administration until noon on day of discharge. The mean (SD) discharge time for the university medical center was 2:21 PM (182 minutes), suggesting that our convention of using noon as the time of discharge for the full sample introduces a modest underestimate in calculations of the hospital length of stay.

Several measures also provided information about risk associated with care in alternative settings. Worst SaO2, a measure that directly reflects derangement in pulmonary function, was defined as the lowest oxygen saturation obtained on room air during a specified time period. Worst SaO2 values were recorded for the time spent in the emergency department, the first 3 nursing shifts on the inpatient unit, and the first 24 hours of hospitalization (as defined earlier). Mild, moderate, and severe asthma episodes were defined on the basis of worst SaO2 values of 93% or greater, 90% to 94%, and less than 90%. At least 1 SaO2 value on room air was recorded in the first 24 hours for 433 (97.7%) of 443 episodes. For the remaining 10 episodes, the following scoring rules were used to assign episodes to 1 of the 3 severity categories. Episodes in which the worst SaO2 was less than 90% despite supplemental oxygen (n=7) were assigned to the most severe category. Episodes in which the worst SaO2 values were normal but high levels of supplemental oxygen (50%-100%) (n=3) were being administered were also assigned to the most severe category. In all 3 of these episodes, children were admitted directly to the critical care unit (CCU). Based on these conventions and observations of worst SaO2 in the first 24 hours, all 443 episodes were placed in 1 of 3 peak severity levels.

Worsening severity, indicating increased risk, was determined on the basis of worsening SaO2 severity category from emergency department to inpatient settings for the 413 episodes (93%) that had SaO2 values recorded in both places. Deterioration in terms of a substantial increase in frequency of nebulized medication was defined as an increase in frequency per 4-hour period of nebulized medication use by 2 or more (eg, from a single administration in 4 hours to 3 administrations in 4 hours). Critical care unit transfer was the term used to identify episodes in which a child was initially admitted to a regular inpatient unit but later transferred to the pediatric CCU.

ANALYSIS

Denominators for calculation of county-wide hospitalization rates were based on the 1990 US Census. During the 5-year observation period, the 198 953 children younger than 19 years in the 1990 census accounted for 992 965 child-years at risk. Proportions derived from data on episodes selected through random sampling were calculated with and without weighting to reflect sampling fractions. Because the proportions of mild and severe episodes from the 3 socioeconomic areas were not different statistically27 and because overall proportions of mild and severe episodes were virtually identical with and without weighting to adjust for different sampling rates, unadjusted rates are presented below and primary analysis was based on unweighted data. The calculation of SEs for rates was based on the Poisson distribution. The Student t test was used to assess statistical significance for differences between 2 means, and the F test was used to assess significance for differences among multiple means.

sions constituted 10.4%, 41.8%, and 47.9% of all hospitalizations, respectively. Based on weighted analysis, mild, moderate, and severe admissions constituted 10.3%, 42.4%, and 47.3% of all hospitalizations, respectively. For a large proportion of admissions classified in the severe range, worst SaO2 values reached the severe level only in the emergency department. Using only the worst inpatient SaO2 values to classify severity, mild, moderate, and severe admissions constituted 21.3%, 51.6%, and 27.1% of all hospitalizations. Among the 207 admissions that were severe at any time, close to half of these (45.9%) were severe only while in the emergency department.

FREQUENT NEBULIZED MEDICATION USE, SaO2 VALUES, AND LENGTH OF STAY

Nebulized medication administration data was available for 434 (98.0%) of 443 cases. The 9 episodes for which there was no information on nebulized medication use were excluded from the analysis that follows. As shown in the Figure, nebulized medication was never administered frequently following arrival on the inpatient unit for 120 (27.1%) of episodes. Use of nebulized medication infrequently following arrival was strongly associated with better SaO2 values in the emergency department. Between children with and without frequent nebulized medication after admission, differences in mean values were highly significant for worst SaO2 (90.3% with vs 91.7% without, t=2.84, df=408, P=.005) and best SaO2 (94.1% with vs 95.3% without, t=3.87, df=278, P<.001) in the emergency department. Among those without frequent nebulized medication after admission, 98.3% had best emergency department SaO2 values of 90% or greater, whereas among those with frequent nebulized medication after admission, only 78.9% had best emergency department SaO2 values of 90% or greater. At the comple-
tion of 3 nursing shifts, children remained hospitalized in 78.6% of episodes, yet only 19.0% continued to receive frequent nebulized medication. The mean (median) number of nursing shifts children received frequent nebulized medication treatments was 2.2 (2.0), whereas they remained hospitalized for a mean (median) of 6.7 (6.0) nursing shifts. The difference between these means (4.5 shifts) accounted for 67.1% of the hospital stay and was highly significant statistically ($t = 28.0$, $df = 429$, $P < .001$).

The relationship between frequent medication use and length of stay was also expressed as the number of nursing shifts for which children remained hospitalized despite treatment schedules in which nebulized medications were used infrequently. The proportion of episodes remaining hospitalized more than 1, 2, 3, and 6 nursing shifts beyond the last period with frequent nebulized medication use were 76.1%, 63.6%, 45.4%, and 14.8%, respectively.

When considering the implications for alternative settings of these findings on duration of frequent nebulized medication and length of stay, it should be recognized that children were generally treated for an extended period in the emergency department prior to admission, and admissions often occurred late at night. For the university hospital where precise times of presentation and departure from the emergency department were available in computer records, the mean (SD) time spent there was 5.7 (2.4) hours. Sixty-one percent of admissions occurred between the hours of 6 PM and 4 AM.

DETERIORATION

Comparison of severity level after arrival on the inpatient unit with that determined in the emergency department provided 1 indication of deterioration. These comparisons exclude 30 episodes in which SaO$_2$ values were not obtained in either the emergency department or the inpatient unit. Among the 79 episodes classified as mild in the emergency department, 54.4% had a fall in SaO$_2$ following arrival on the inpatient unit that was sufficient to change the classification; for 38 (48.1%) severity increased to moderate, and for 5 (6.3%) severity increased to severe. Among those episodes becoming severe, none reached a value for SaO$_2$ as low as 85%. Of the 164 episodes that were moderate in the emergency department, 32 (19.5%) became severe. Among those becoming severe, 4 reached values for SaO$_2$ of 85% or less.

Although increase in severity level determined on the basis of worst SaO$_2$ in room air was relatively common, deterioration to a critical level was unusual. After arrival on the inpatient unit, the frequency of nebulized medication treatments increased in a subsequent 4-hour period in 39 (9.0%) of the 434 episodes for which this information was available. A substantial increase (increase in frequency per 4-hour period by 2 or more) in nebulized medication use occurred in only 8 (1.8%) of episodes. Critical care unit admission occurred with 31 (7.0%) of the 443 asthma hospitalizations, but 28 (90.3%) of these 31 admissions went directly to the CCU from the emergency department. Only 3 (0.7%) of the 415 patients admitted to the regular inpatient unit subsequently were transferred to the CCU.

One of the 3 involved a 7-year-old child who was transferred to the CCU not because of deterioration but because the attending pediatrician elected to use hourly treatments with nebulized medication. This intensity of treatment was not routinely permitted on regular inpatient units at the time. Another involved a 9-year-old child whose transfer to the CCU was completed 4 hours after the nurse on the regular inpatient unit notified the house officer that air movement was poor and that the SaO$_2$, without supplemental oxygen, remained in the 85% to 89% range despite nebulized albuterol administered every 2 hours. In response to these observations, supplemental oxygen was increased to 100% and 2 consecutive nebulized albuterol treatments were administered. Substantial improvement was noted prior to transfer. The third involved a 12-month-old child who, shortly after receiving an albuterol nebulizer treatment, developed increased respiratory distress, cyanosis, and SaO$_2$ of 62% while in 35% oxygen. This followed emergency department and inpatient treatment spanning 15 hours in which the child’s course had been satisfactory. This infant was then treated with increased supplemental oxygen, 3 additional doses of aerosolized albuterol, subcutaneous epinephrine, and aerosolized terbutaline. At the time of arrival in the CCU 3 hours later, the infant was playful, respiratory distress had resolved, and SaO$_2$ on 100% oxygen was 97%.

AGREEMENT AMONG MEASURES

Worst SaO$_2$, length of stay, and duration of frequent nebulized medication were correlated, although correlation between measures expected to reflect duration of the asthma exacerbation (length of stay, duration of frequent nebulized medication) were more strongly correlated with one another than with the measure of peak physiologic derangement, worst SaO$_2$. The Pearson correlation coefficients between worst SaO$_2$ (as a continuous variable) and length of stay and worst SaO$_2$ and periods receiving frequent nebulized medication were 0.16.
(P<.001) and 0.21 (P<.001), respectively. The correlation coefficient between length of stay and periods receiving frequent nebulized medication was 0.63 (P<.001).

The relationship between these measures is also apparent when Sao2 is treated as a categorical variable. For episodes classified on the basis of worst Sao2 as mild, moderate, and severe, the mean lengths of stay (in nursing shifts) were 4.9 hours, 5.8 hours, and 7.0 hours, respectively (F = 6.5, P = .002). Similarly, the mean number of nursing shifts receiving frequent nebulized medications in mild, moderate, and severe episodes were 1.6, 1.7, and 2.5, respectively (F = 8.9, P<.001).

COMMENT

Our observations describe inpatient care patterns that were shaped gradually over decades. Prevailing influences in this evolutionary process included advances in technology and goals for improving patient care. Cost considerations were secondary, and opportunities for cost savings felt relatively unimportant. Now, increasingly compelling financial constraints make our findings highly relevant. These findings provide important information about type and intensity of interventions, duration of their use, and level of risk with asthma hospitalizations, all of which are critical considerations in structuring lower-cost alternatives to hospitalization.

PREVIOUS STUDIES

Several previous articles have proposed short-stay treatment and triage programs (sometimes referred to as “holding rooms” or “observation units”) for management of acute asthma exacerbation.10-13 Although each of these publications presents evidence supporting the feasibility of short-stay programs, evaluations of this service as an alternative to pediatric inpatient care have been limited by use of outmoded therapy.11-14 Study populations including large proportions of adults,13-15 or failure to follow up patients through the illness episode,12 None of these studies were designed to meet the primary objective of our study, to estimate the proportion of asthma admissions from a well-defined childhood population that might be cared for in a short-stay program or other alternative setting. The large, recent study of Gouin et al.10 for example, used a before-and-after design to determine effects on asthma admission rate for the emergency department of an urban, tertiary care, children’s hospital. Although quite valuable in addressing this objective, this study was not designed to assess the importance of care alternatives for a community’s children nor to assess risk associated with alternative-setting care. Patients served by a tertiary care institution may not be representative of all patients visiting a community’s emergency departments. Further, because no information was provided on the hospital course of children admitted, there is no basis for judgment about the possibility that further reduction in hospital admissions might have been achieved. Finally, the before-and-after design cannot address the possibility that secular trends in hospitalization practices, not the introduction of the short-stay unit, account for part of the observed reduction in hospitalization.

SERVICE REQUIREMENTS AND THEIR DURATION

For most asthma hospitalizations, technological components of care are limited to supplemental oxygen, nebulized and oral medications, intravenous infusions, oxymetry, and regular nursing observations. These services, as well as some of a higher level of intensity, are already provided for some chronically ill children in their homes regularly.10-22

Most interventions could be used for relatively short periods. For many admissions (21.3%), the child never reached a Sao2 value considered abnormal (<95%) after arriving on the inpatient unit. If the time of admission to an alternative setting were similar to the present time of inpatient admission, these children might never need supplemental oxygen following admission. For a substantially larger (72.9%) proportion of episodes, the child never reached a Sao2 value in the severe range (<90%) after arriving on the inpatient unit. For this group, frequent nebulized medication was administered for more than 1 full nursing shift in 42.2% of cases, and for more than 3 full nursing shifts in only 14.3% of episodes. Supplemental oxygen administration would be appropriate for the many children in this group who had worst Sao2 values between 90% and 94%.

RISK

Risk estimates were based on worst Sao2 values and on observations suggesting deterioration occurred. When interpreting estimates of risk for this community, it should be understood that, during the study period, children who were receiving nebulized medication at intervals shorter than 2 hours at the time of admission were generally admitted to the CCU rather than the regular inpatient unit. Admission of children with asthma exacerbation to the CCU was far more common than transfer to the CCU.

Although it was relatively common for the worst Sao2 after arrival on the inpatient unit to result in placement in a higher severity category than the worst Sao2 in the emergency department, appropriate response to this form of deterioration—generally increasing the level of supplemental oxygen—could usually be accomplished readily in an alternative setting. More worrisome levels of deterioration, signaled by an increase in the frequency of nebulized medication per 4-hour period by 2 or more or by transfer to the CCU, were uncommon, occurring in only 1% to 2% of episodes. Had they been cared for in alternative settings, children in whom these events occurred would almost certainly have been candidates for transfer to inpatient care. Although transfer to inpatient care is undesirable and would be inconvenient for families and providers, it seems that risk for true adverse outcomes associated with such transfers is quite low. We believe that the 3 children (0.7%) admitted initially to a regular inpatient unit but later transferred to the CCU could have been safely transferred to the hospital from an alternative setting with appropriately trained staff, proper supervision and back-up, and a well-functioning CCU transport system. A CCU transport system already exists in...
this community, so its occasional use for children in alternative settings would increase the overall cost of this service very little. Additional evidence in support of safety is provided by a prior study of deterioration among children admitted with any diagnosis to regular inpatient units. Deterioration was both uncommon and evolved during a sufficiently long period that nurses alerted physicians no less than 3 hours prior to eventual transfer to the CCU.

Although these observations provide reassurance, they also indicate that, to ensure timely identification of deterioration and transfer to hospital care, careful monitoring is essential to alternatives designed to avoid hospitalization.

LIMITATIONS

This retrospective study in which key data were obtained from medical record review can only provide rough estimates of the effects of new, alternative services on patterns of care for acute childhood illness now treated in the hospital. We speculate, for example, that use of nebulized medication administration as a measure of severity provides an overestimate. Our clinical experience is that bronchodilators are often administered during a hospital stay simply because they were previously scheduled by physician order, not because clinical assessment of the child indicates the medication is needed.

Our choice of SaO2 as a measure of risk and severity, although driven in part by its ease of use, widespread adoption, and retrievability in record review, was also based on substantial evidence supporting its validity. Arterial oxygen saturation directly reflects derangement in pulmonary function, is useful in predicting hospitalization and intensity of treatment,\textsuperscript{23,25} has better predictive value than peak flow,\textsuperscript{26} correlates well with some clinical scores of severity,\textsuperscript{27,28} and is responsive to treatment with bronchodilators.\textsuperscript{26} In some children with acute asthma episodes, however, SaO2 falls significantly (2 percentage points or more) with bronchodilator treatment.\textsuperscript{26,20,30} Apparently due to an increase in ventilation-perfusion mismatch attributed to greater relaxation of vascular than bronchial smooth muscle.\textsuperscript{31} For several reasons, this effect on SaO2 is unlikely to have an important effect on findings and implications of this study. Virtually all studies of bronchodilator effects on SaO2 in asthma episodes find that mean values improve with treatment.\textsuperscript{23,26,28} Tal et al,\textsuperscript{30} who observed a fall among 9 of 18 subjects in whom SaO2 was measured at 5, 15, and 30 minutes, noted that the mean (92.1%) had returned to baseline by 30 minutes after treatment. Such transient changes will often go undetected in a busy clinical setting such as that studied. Most observers found significant falls in SaO2 to occur in a small proportion (<20%) of their subjects.\textsuperscript{26,32,33} Finally, given the widespread use of inhaled bronchodilators, the extent to which worst SaO2 values were lowered owing to bronchodilator use among children included in this study is likely to be no different from children with acute asthma exacerbation elsewhere.

Specific characteristics of the alternative services developed, the manner in which they are used in individual communities, and the cost of these services will ultimately determine the reduction in childhood hospitalization achieved. Eligibility guidelines for alternative services, the complexity and intensity of interventions permitted, time limitations imposed, and facilities and protocols for management of deterioration will be important determinants. Safety as well as comfort of patients and their families of course should be primary determinants. As with hospitalization rates, one may expect variation among communities in rates of use for alternative services. A complex interaction between morbidity on one hand and family, health system, and provider attributes on the other may influence this variation.\textsuperscript{16}

A further limitation derives from the fact that this study was based in 1 community. It should be recognized that potential for reduction of asthma hospitalization probably is substantially greater in many other communities than in Rochester. Childhood asthma hospitalization rates for Boston and New Haven were found to be 4-fold and 2-fold greater, respectively, than the rate for Rochester.\textsuperscript{4} Moreover, the proportions of admissions for asthma that were mild (worst SaO2 of \(\geq 95\%\)) have been found to be significantly greater in these other 2 communities.\textsuperscript{34}

CONCLUSIONS

This study suggests that alternative settings restricted to children with mild or moderate illness at admission might nevertheless care for approximately 70% of all asthma exacerbations now treated by hospitalization. Providing frequent nebulized medication for 1 nursing shift or less would be sufficiently long to care for almost 60% of this mild to moderate group.

Findings also suggest that many hospital admissions could be avoided altogether and many hospital stays might be shortened significantly even without new services. A substantial portion of hospital admissions (27.1%) occurred after the child no longer received frequent nebulized bronchodilator therapy. We speculate that these admissions seemed necessary to physicians because of family fatigue or anxiety, or because of concerns about the ability of the family to adhere to treatment recommendations. On average, children received nebulized bronchodilator therapy on a schedule considered safe for home use for almost 70% of their hospital stay. We speculate that much of the stay beyond the period with frequent nebulized medication is explained by a misfit between medical care routines and the typical patterns of family life and illness resolution. Most asthma admissions occurred between 6 PM and 4 AM. Discharge after the first period with infrequent nebulized medication would often mean sending a family home in the middle of the night after spending many hours in the emergency department. Although asthma episodes may resolve at any time of day, discharge decisions have traditionally been made during morning hospital rounds by community-based physicians and work rounds by residents. To make discharge decisions at other times requires additional clinical evaluations and additional communication. Notably, in-home nursing is a form of alternative setting care\textsuperscript{15} that may be able to address each of these reasons for apparently unnecessary admissions and prolonged hospital stays.
The potential for reduction of asthma hospitalization seems large. Substantial investment in further studies focused on evaluating risk for specific illness episodes and defining the most appropriate eligibility criteria for care in alternative settings is likely to result in considerable cost savings.

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