POLICY

Effects of Continuity of Care on Emergency Department Utilization in Children With Asthma

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Asthma is among the most common respiratory diseases, with 300 million affected people worldwide, according to the World Health Organization.[1] About 1 in 10 American children suffered from the disease in 2009.[2] Children with asthma are prone to acute, sometimes severe, attacks. Between 2005 and 2007, US children with asthma visited the emergency department (ED) 9.9 times per year on average, compared with the average 7.5 annual visits for US patients with asthma of all ages.[2]

The US Agency for Healthcare Research and Quality has indicated that surveillance of asthma care should include daily symptom burden and acute avoidable events due to asthma, such as asthma ED visit rate and asthma admission rate. In particular, asthma ED visits reflect poor disease management on the part of providers and patients.[3]

The US Institute of Medicine defines continuity of care (COC) as the condition of "care over time by a single individual or team of health professionals."[4] Within this long-term relationship, healthcare providers can better manage the chronic conditions of their patients because of their familiarity with their patients' medical history and greater ability to communicate with their patients because of repeat interactions. COC leads to greater patient satisfaction; less disability and pain; and decreased ED utilization, hospitalization, and medical costs.[5-8]

For patients with asthma, research has shown that higher continuity of asthma care can decrease asthma ED utilization.[9-12] However, most of these investigations were conducted in Western countries; COC has not been well studied in Asian children with asthma. We therefore aimed to examine whether continuity of ambulatory asthma care could lower asthma ED use among children with asthma in Taiwan. We adopted 2-part hurdle regression models to analyze the data for all children with asthma, and separately for those who had ED visits.

ABSTRACT

Objectives: To examine whether continuity of ambulatory asthma care can lower asthma-specific emergency department (ED) utilization by children with asthma in Taiwan.

Study Design: Retrospective cohort study based on claims data.

Methods: We used the Taiwan National Health Insurance Dataset, 2006 to 2009. The study population was new asthma patients aged 0 to 17 years in 2007, and every case was observed for 2 years. We used the Continuity of Care Index (COCI) to calculate the continuity of ambulatory asthma care in the first year, and estimated the asthma-specific ED utilization in the second year. Two-part hurdle regression was used for statistical analysis.

Results: The 29,277 patients in our study had an average COCI of 0.68 (± 0.31), and 42.3% of patients had an index of 1. More than 1 in 20 patients—1641 (5.61%)—had at least 1 asthma ED visit, and the mean number of visits per user was 1.46 (± 0.99). After controlling for covariates, the groups with medium and low continuity of ambulatory asthma care had 21% (odds ratio [OR], 1.21; 95% CI, 1.06-1.39) and 38% (OR, 1.38; 95% CI, 1.21-1.58) higher asthma-related ED utilization, respectively, than the group with high COCI. However, among users, the number of ED visits was not statistically correlated to the continuity of ambulatory asthma care.

Conclusions: High continuity of ambulatory asthma care can decrease asthma-specific ED utilization risk in children with newly diagnosed asthma in Taiwan. We suggest that providers and the government reinforce the use of follow-up care and education for high-risk groups to improve the continuity of ambulatory asthma care.

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Take-Away Points

This was a retrospective cohort study using Taiwan's National Health Insurance Dataset, aimed to examine the effects of continuity of ambulatory asthma care on asthma-related emergency department (ED) utilization for children with asthma. We used 2-part hurdle regression.

■ For the first part, higher continuity of ambulatory asthma care significantly decreased the risk of having asthma-specific ED visits.

■ For the second part, which examined the asthma-specific ED users only, continuity of ambulatory asthma care did not significantly correlate with the number of visits.

■ Better continuity of ambulatory asthma care might improve outcomes for children with asthma.

METHODS

Data Source

In 1995, Taiwan implemented a single-payer, compulsory national health insurance (NHI) program that now enrolls nearly 100% of residents. Universal insurance coverage and low co-payments minimize the economic barrier to care for patients. With no gatekeeper program, patients choose the provider of their choice.

The NHI data set is a national, population-based healthcare claim database containing detailed records of outpatient visits, ED visits, and hospital admissions (including diagnosis, procedures, medication, provider information, and expense). We used the data for 2006 to 2009. By using secondary data analysis, approval from an institutional review board was not necessary for this study.

Study Design and Study Subjects

We conducted a retrospective cohort study of new patients with asthma aged under 18 years in 2007. New asthma patients were defined as those having 2 outpatient or ED visits, or 1 admission, due to asthma (The *International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] code for primary diagnosis of 493.xx) in 2007 but without such records in the previous year.[12,13] The date of the patient's first asthma visit/admission was called the index date, and all patients were observed for 2 years after the index date. Excluded subjects were those who died during the observation period, had an "unknown" study variable, or whose primary care physician or clinic/hospital could not be defined.

The first year of observation was considered the COC period. The number of asthma-related outpatient visits in this period was used to calculate the COC index, which represented the extent of care provided by the primary care physician. Previous studies have cautioned that bias may occur in calculating the COC index if the patient had too few outpatient visits; as a result, we included only patients

with at least 3 asthma-related outpatient visits in the COC period.[14-17] The second year of observation was the outcome period, used to estimate asthma ED utilization.

The 74,705 new 0- to 17-year-old patients with asthma in 2007 represented an incidence rate of 1.5% of the 5,002,123 children in Taiwan. After excluding patients who died during the observation period (n = 7), those with too few asthma outpatient visits in the COC period (n = 41,572), those with any study variable unknown (n = 834), and those whose primary care physician or clinic/hospital could not be defined (n = 3015), we studied 29,277 children with asthma.

Variable Measurement

Outcome variables. The outcome variables included a) asthma ED visit or not, and b) the number of asthma ED visits in the outcome period. An asthma ED visit was defined as an ED visit with a primary or secondary diagnosis of asthma. Because the following were unrelated to regular health-seeking behavior, we excluded any ED visit for injuries, poisoning (*ICD-9-CM* 850-995) or those with supplementary classifications (V-codes), such as chemotherapy.[16,17]

Continuity of care. The independent variable was continuity of asthma-specific ambulatory care. Jee and Cabana categorized the types of indexes for measuring COC.[18] We opted to use a dispersion-type index because it is easy to calculate, is not prone to be affected by the number of visits, and considers all providers. We used the Continuity of Care Index (COCI),[19] a dispersion-type index adopted by numerous studies.

The COCI for asthma-specific ambulatory care was calculated by using the number of a patient's outpatient visits for asthma (primary or secondary diagnosis) at a clinic or hospital during the COC period. The equation is as follows:

$$COCI = \frac{\sum_{i=1}^{M} n_i^2 - N}{N(N-1)}$$

N represents the total number of asthma-related outpatient visits, n is the number of asthma-related outpatient visits to a physician, i is a given physician, and M is the number of physicians.

The COCI value ranges from 0 to 1, with higher values representing better COC. We defined the high COC group (42.3% of subjects) as COCI = 1, indicating that all of a patient's asthma care in the COC period was provided by the same physician. All other subjects were dichotomized

by their median of COCI into the medium COC group (COCI = 0.43-0.99) and the low COC group (COCI <0.43).

Covariates. Patient characteristics included sex, age (0-4, 5-9, or 10-17 years), income status, urbanization level of insurance registry district, and enrollment in the asthma pay-for-performance (P4P) program. Since health status during the COC period may impact the outcome, we used the total number of asthma outpatient visits as a proxy for health status and disease severity,[10,12,15,16,20] categorizing subjects into those with low (3-4), medium (5-8), or high (≥9) visits based on the tertile. We also observed whether the patient had asthma ED visits and the total length of stay for asthma-related hospital admissions during the COC period. For providers, we included sex and mean number of asthma outpatient visits in 2007 and 2008 for the primary care physician responsible for the most asthma care for the patient. We also controlled for the place at which the patient most often received care by the primary care physician, sorting them into hospitals (with fewer than 250, 250 to 499, and 500 or more beds) and nonhospital clinics.

Statistical Analyses

All analyses were conducted using SAS version 9.2 (SAS Institute, Cary, North Carolina). Descriptive statistics included percentage, mean, standard deviation, and minimum and maximum of the study variables. The χ^2 test and Kruskal-Wallis test were used for bivariate analyses. The significance level was set as 0.05.

In multivariate analysis, an excess of zeroes (ie, no ED visits) may bias the parameter estimation and affect the inference.[21] Most previous studies analyzed all patients and did not take into account the influence of having many patients with no asthma ED visit. In this study, 94.39% of subjects had no asthma ED visit during the outcome period; we therefore used hurdle regression, as developed by Mullahy, rather than multiple regression, Poisson regression, or negative binominal regression.[22] Hurdle regression uses a 2-part model: the first component was used to model whether the patient had an asthma ED visit or not by logistic regression; in the second component, which focused on the users only, the number of asthma ED visits was modeled using a left-truncated Poisson regression.

RESULTS

The average COCI of our study subjects was 0.68 (± 0.31) and, of all 29,277 subjects, 12,383 (42.30%) were in the high COC group (COCI = 1), 8317 (28.41%) in the medium COC group (COCI = 0.43-0.99), and 8577 (29.30%) in the low COC group (COCI <0.43). The characteristics of all study subjects and of each COC group are presented in Table 1. All characteristics, except sex and income status, were significantly related to continuity of ambulatory asthma care (*P* <.001).

Table 2 shows asthma ED utilization during the outcome period. Among all subjects, 1641 (5.61%) had at least 1 asthma ED visit, and the mean number of visits for the users was 1.46 (± 0.99). In the high COC group, 3.96% of patients had at least 1 asthma ED visit; the figures were 6.60% of patients in the medium and 7.02% of patients in the low COC groups. The difference was statistically significant (*P* <.001). For ED users, the average number of asthma ED visits was 1.42 (± 0.89) in the high COC group, 1.44 (± 0.99) in the medium COC group, and 1.53 (± 1.05) in the low COC group; this difference was statistically significant (*P* <.001).

The results of hurdle regression are presented in Table 3. The first component (binary OR) of the hurdle regression was used to analyze whether continuity of ambulatory asthma care reduced the risk of an asthma-related ED visit. As a crude result, the risks for the medium and the low COC groups were significantly higher than for the high COC group (OR, 1.72; 95% CI, 1.51-1.94; and OR, 1.83; 95% CI, 1.62-2.07, respectively). After controlling for the covariates mentioned above, the adjusted risks of an asthma-related ED visit for the medium and low COC groups were 1.21 (95% CI, 1.06-1.39) and 1.38 (95% CI, 1.21-1.58) times that of the high COC group, respectively.

The second component (count risk ratio [RR]) of hurdle regression was used to analyze whether continuity of ambulatory asthma care affected the number of asthma ED visits for the users only. As a crude result, the number of ED visits of the low COC group was 23% higher than that of the high COC group (95% CI, 1.04-1.45), but the medium and high COC groups did not differ significantly (RR, 1.03; 95% CI, 0.86-1.23). After controlling for covariates, the number of ED visits did not differ significantly between the medium and high COC groups (RR, 0.86; 95% CI, 0.72-1.04) or between the low and high COC groups (RR, 1.00; 95% CI, 0.84-1.19).

DISCUSSION

We found that children in Taiwan with newly diagnosed asthma generally had high continuity of ambulatory asthma care. The average COCI was 0.68 (± 0.31), while fully 42% of the patients had a COCI of 1, meaning they received all their asthma-related care from a single physician during the first year of observation. This high level of COC in Taiwan may be attributed to several factors. First, in addition to extensive insurance coverage and low co-

■ **Table 1.** Characteristics of the Study Subjects

	Total Patients N = 29,277		Continuity of Ambulatory Asthma Care			
			Low (<0.43) n = 8577	Medium (0.43-0.99) n = 8317	High (1) n = 12,383	P^a
Variable	n	%	%	%	%	
Demographic characteristics						
Sex						
Male	18,045	61.64	29.06	28.77	42.17	>.05
Female	11,232	38.36	29.68	27.82	42.49	
Age, years						
0-4	15,041	51.37	31.03	31.00	37.97	<.001
5-9	10,858	37.09	28.31	26.93	44.76	
10-17	3378	11.54	24.75	21.61	53.64	
Low-income status						
No	28,850	98.54	29.29	28.45	42.27	>.05
Yes	427	1.46	29.98	25.76	44.26	
Urbanization level of insurance registry districts						
Metropolitans	6783	23.17	25.53	28.32	46.14	<.001
Province city	4320	14.76	29.21	27.89	42.89	
County city	8385	28.64	29.99	28.61	41.40	
Township	9479	32.38	31.35	28.65	39.99	
Remote districts	310	1.06	30.97	24.52	44.52	
Health status in COC period						
Asthma P4P program						
Not enrolled	17,363	59.31	27.57	26.49	45.94	<.001
Enrolled	11,914	40.69	31.81	31.20	36.99	
Number of asthma outpatient visits						
Low (3-4 visits)	10,978	37.50	32.06	13.13	54.81	<.001
Medium (5-8 visits)	10,054	34.34	29.68	31.25	39.07	
High (≥9 visits)	8245	28.16	25.14	45.29	29.57	
Asthma ED visits						
None	26,841	91.68	28.53	27.80	43.68	<.001
Yes	2436	8.32	37.77	35.14	27.09	
Total days of asthma admissions						
None	27,805	94.97	28.91	27.89	43.20	<.001
Low (1-3 days)	563	1.92	37.66	36.94	25.40	
Medium (4-5 days)	475	1.62	36.21	37.68	26.11	
High (≥6 days)	434	1.48	35.48	40.32	24.19	
Primary physician						
Sex						
Male	24,434	83.46	28.98	28.11	42.91	<.001
Female	4843	16.54	30.91	29.90	39.19	
Annual asthma outpatient care volume						
Low (<875 patient visits)	9810	33.51	34.75	26.32	38.93	<.001
Medium (875-2494 patient visits)	9724	33.21	30.14	30.00	39.86	
High (≥2495 patient visits)	9743	33.28	22.96	28.92	48.12	
Primary care place, scale						
Clinic	17,739	60.59	32.55	26.70	40.75	<.001
Hospital, <250 beds	1770	6.05	24.52	31.24	44.24	
Hospital, 250-499 beds	2407	8.22	24.76	31.41	43.83	
Hospital, ≥500 beds	7361	25.14	24.09	30.85	45.06	

COC, continuity of care; ED, emergency department; P4P, pay-for-performance.
[a]Chi-squared test.

■ **Table 2.** Asthma-Related Emergency Department Utilization in Outcome Period of Study Subjects

	Had at Least 1 Asthma ED Visit			Number of Asthma ED Visits of Users Only[a]			
	n	%	P^b	Mean	SD	Max	P^c
Total patients (N = 29,277)	1641	5.61		1.46	0.99	9	
Continuity of ambulatory asthma care							
High (1.00)	490	3.96	<.001	1.42	0.89	9	<.001
Medium (0.43-0.99)	549	6.60		1.44	0.99	9	
Low (<0.43)	602	7.02		1.53	1.05	8	

ED indicates emergency department; max, maximum.
[a]All minimums equaled 1.
[b]Chi-squared test.
[c]Kruskal-Wallis test.

payments for outpatient visits, Taiwan has no compulsory referral scheme or gatekeeper program, giving patients great freedom in choosing care providers. Second, the low birth rate and high level of education of parents allow them to focus on disease management for their children with chronic conditions like asthma. Third, the government began an asthma P4P program in 2001 based on a continuing care model, encouraging clinics and hospitals to provide patient-centered care focused on disease management, enforcement of follow-ups, and enhancement of patient self-care ability.

This study supports the results of Cree and Cyr et al.[10,11] Higher continuity of ambulatory asthma care could lower the risk of using emergency care for children with asthma, with a trend of a dose-response effect. Hong et al studied COC in older adults in South Korea with 4 different chronic diseases, including asthma and diabetes, and found increased COC associated with a reduction in the risk of ED visits. This negative correlation was greater for asthma than for diabetes.[12] In Taiwan, previous research on all patients and those with diabetes found that higher levels of COC could lower ED visits and hospital admissions.[13,16,17] Thus, these findings support government programs like P4P to improve COC for patients with diabetes. Since our research showed that higher COC also had positive impacts on children with asthma, we believe this may help the government to plan programs to improve COC for patients with asthma in order to reduce the risk of ED visits.

With higher COC, patients and their physicians develop greater familiarity with each other as well as higher levels of trust. The physician can then more efficiently manage the medical conditions of returning patients, and patients are more likely to comply with instructions, subsequently leading to fewer asthma attacks. A previous study found that when providers designated someone to follow up with patients with asthma who were discharged from the ED, patients were more likely to have follow-up visits and had better quality of life, a care plan, and fewer asthma symptoms.[23] Moreover, because Taiwan has very accessible healthcare, patients who trust their physician can substitute ambulatory care for ED visits. Christakis et al found no statistical correlation between COC and the risk of asthma-related ED visits in children with asthma in a health maintenance organization, but did find one for those with Medicaid.[9] This finding supports the principle that universal insurance coverage and low co-payments of the NHI in Taiwan eliminate the economic barriers to high COC for children with asthma.

In terms of the number of asthma-related ED visits, we used the second component of hurdle regression, which focused on patients who had at least 1 asthma ED visit. All previous studies analyzed the number of asthma ED visits for all patients, including those with no ED visits. Cree et al found that high continuity of asthma care could decrease the number of asthma ED visits by 63%.[10] In Canada, increasing the asthma COCI by 0.1 decreased the number of asthma-related ED visits by 19% for asthma patients aged 12 to 17 years.[11] The 2-part hurdle regression reflects the sequential decision-making process for healthcare services. The response variable of the first part is whether to use the ED or not—a decision more likely to be decided by the patient and family, and thus, more likely correlated with personal characteristics. The response variable of the second part is the number or cost of visits, which is more likely to be associated with the characteristics of the healthcare system.[24]

Our research showed a significant correlation in the first part—that the continuity of ambulatory asthma care influenced whether newly diagnosed children with asthma in Taiwan went to the ED—but not in the second

■ **Table 3.** Hurdle Regression Analysis for the Effects of Continuity of Ambulatory Asthma Care on Asthma-Related ED Utilization Among Children With Asthma

	Crude Results				Adjusted Results[a]			
	Binary OR (95% CI)	P	Count RR (95% CI)	P	Binary OR (95% CI)	P	Count RR (95% CI)	P
Continuity of ambulatory asthma care (reference group = high [1.00])								
Medium (0.43-0.99)	1.72 (1.51-1.94)	<.001	1.03 (0.86-1.23)	>.05	1.21 (1.06-1.39)	<.01	0.86 (0.72-1.04)	>.05
Low (<0.43)	1.83 (1.62-2.07)	<.001	1.23 (1.04-1.45)	<.05	1.38 (1.21-1.58)	<.001	1.00 (0.84-1.19)	>.05

ED indicates emergency department; OR, odds ratio; RR, risk ratio.
[a]Controlling for patient's sex, age, low-income status or not, urbanization level of insurance registry districts, enrollment in the asthma pay-for-performance program, number of asthma outpatient visits in the continuity of care (COC) period, asthma ED visits in COC period or not, total days of asthma admissions in COC period, sex of the primary physician, annual asthma outpatient care volume of the primary physician, and scale of the primary care place.

part, the number of asthma ED visits for users only. In most cases, inexperienced parents went to the ED when the first asthma attack happened; later, they were better able to control symptoms. Most of our patients who had at least 1 asthma ED visit went to the ED only once in the outcome period, which may have caused the statistical differences between COC groups to remain undetected.

Limitations and Strengths

The limitation to our study is common to secondary data analysis. The NHI database contains no information on the outcomes of medical examinations, so we were unable to directly measure the severity of asthma. Therefore, we controlled for the number of asthma outpatient visits,[10,12,15,16,20] whether or not the patient made an asthma-related ED visit, and the total days of asthma hospitalization during the COC period, in order to diminish the effect of disease severity.

Our study has several advantages, however. First, selecting new patients as the study subjects helped avoid the effects of past disease history and care experience on later COC and medical use. Most previous studies included all patients, whether their asthma was ongoing or newly developed, except for a Korean study of patients aged 65 to 84 years with newly diagnosed asthma or other chronic diseases, and a Taiwanese study of the effect of COC on avoidable admission for patients with diabetes, which controlled for the effect of being a new patient.[12,13] We chose new pediatric asthma patients as our study subjects to more specifically examine the relationship between COC and ED use. Second, using a longitudinal study design helped in determining the temporality of events. Van et al believed that COC and outcome may affect each other; worse outcome or low satisfaction may trigger the

patient to seek the care of other physicians and further decrease COC.[7] In this study, COC was measured in the first year and the outcome was measured in the second year, to construct clear temporality.

Third, using asthma outpatient visits instead of visits for all conditions to estimate COC can more accurately reflect the actual asthma care received. For instance, Chen and Cheng chose patients with diabetes to calculate the COCI for diabetes-related physician visits.[16] They mentioned that, because of the lack of a compulsory referral system and the high number of outpatient visits in Taiwan, disease-specific COCI could more sensitively examine the relationship between COC and medical use. Therefore, in our study, only asthma-related outpatient visits were counted. Fourth, and finally, Van et al found that many factors influence the correlation between COC and outcomes, such as age and severity of disease, suggesting that these covariates should be controlled for.[7] In our study, we included many covariates in the models to reduce the possible effect on our results of such factors as patient characteristics, enrollment in the P4P program, severity of disease, and care provider characteristics.

CONCLUSIONS

Our study showed that, for children with newly diagnosed asthma in Taiwan, better continuity of ambulatory asthma care could reduce the risk of asthma-related ED visits. We suggest that healthcare providers enhance follow-ups and self-care ability for high-risk patients with asthma with low COC. Also, we suggest that policy makers seek to develop effective ways for all children with asthma to maintain an ongoing relationship with their physician as a way to better control their disease.

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