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Use of Adult-Trained Medical Subspecialists by Children Seeking Medical Subspecialty Care

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Abstract

Objectives—To quantify use of adult-trained medical subspecialists by children and to determine the association between geographic access to pediatric subspecialty care and use of adult-trained subspecialists. Children with limited access to pediatric subspecialty care may seek care from adult-trained subspecialists, but limited data exist on this practice.

Study design—We identified children <16 years old in 2007-2012 Pennsylvania Medicaid claims. We categorized outpatient visits to 9 selected medical subspecialties as either pediatric or adult-trained subspecialty visits. We used multinomial logistic regression to examine the adjusted association between travel time to pediatric referral centers and use of pediatric versus adult-trained medical subspecialists for children with and without complex chronic conditions (CCCs).

Results—Among 1.1 million children, 8% visited the examined medical subspecialists, with 10% of these children using adult-trained medical subspecialists. Compared with children with 30 minutes travel time to pediatric referral centers, children with >90 minutes travel time were more likely to use adult-trained subspecialists (without CCCs: relative risk ratio (RRR) 1.94, 95% confidence interval (CI) 1.79-2.11; with CCCs: RRR 2.33, 95%CI 2.10-2.59) and less likely to use pediatric subspecialists (without CCCs: RRR 0.66, 95%CI 0.63-0.68; with CCCs: RRR 0.76, 95%CI 0.73-0.79).

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Conclusions—Among medical subspecialty fields with pediatric and adult-trained subspecialists, adult-trained subspecialists provided 10% of care to children overall, and 18% of care to children living >90 minutes from pediatric referral centers. Further work should examine consequences of adult-trained medical subspecialist use on pediatric health outcomes and identify strategies to increase access to pediatric subspecialists.

Keywords

pediatric; specialty; subspecialty; referral; consultation; geographic access; barriers to care; travel time

The American Academy of Pediatrics states that access to appropriately trained pediatric subspecialists is necessary for optimal child health and well-being.¹ However, rising rates of chronic illness among children² and the limited supply of pediatric subspecialists^{1,3,4} result in inadequate access to pediatric subspecialists for many children.⁵⁻⁷ Nearly a quarter of families report difficulty accessing needed specialty care,⁶ and pediatricians report long wait times for referrals.⁷ Unequal geographic distribution of pediatric subspecialists⁸⁻¹⁰ creates further barriers, resulting in significant travel distances⁸ and decreased subspecialty use¹¹ for many children.

Given these barriers to pediatric subspecialty care, children and their caregivers may instead seek care from adult-trained subspecialists. In the surgical fields, receipt of care by non-pediatric surgeons has been associated with worse outcomes, prompting recent guidelines describing specific clinical circumstances that warrant pediatric-specific expertise.¹² In contrast, little is known about children's use of adult-trained subspecialists in medical fields, such that even the quantity of care provided to children by adult-trained medical subspecialists is unknown. Using data from 1989-1992, one study found that between 6% and 41% of children with a range of chronic conditions visited only adult-trained medical or surgical subspecialists.¹³ A subsequent study indicated that the proportion of visits by children to non-pediatric subspecialists declined from 2000-2006.¹⁴ Over the last several decades, both the number of pediatric medical subspecialty fields and the number of subspecialists in each field have grown substantially.¹⁵ Thus there is a need to quantify the current use of adult-trained subspecialists by pediatric patients and to understand the degree to which the wide variation in geographic access to pediatric subspecialists^{8,9} is associated with adult-trained subspecialist use.

To understand this issue we used a single-payer Medicaid dataset to examine the frequency with which children with and without complex chronic conditions (CCCs) use adult-trained subspecialists, and to determine whether decreased geographic access to pediatric subspecialists is associated with increased use of adult-trained subspecialists.

Methods

We examined 2007-2012 outpatient and professional claims data for Pennsylvania Medicaid beneficiaries, including managed care and fee-for-service. These data contain final action claims for all Pennsylvania Medicaid beneficiaries, and are provided through ongoing partnership between the University of Pittsburgh and the Pennsylvania Department of

Human Services. We identified children <16 years old and examined subspecialty use during 24 months of claims for each child. We used 24 months of claims due to the relatively infrequent occurrence of subspecialty care, as even children with special health care needs may see subspecialists less than annually.¹¹ To allow adequate observation without requiring continuous enrollment, we excluded children enrolled for <20 of 24 months. This study was approved by the University of Pittsburgh Institutional Review Board.

Outpatient visits were identified using Current Procedural Terminology codes 99201-99215, 99241-99245, 99381-99397, and T1015. The visit provider was classified into one of 3 types: pediatric medical subspecialist, adult-trained medical subspecialist, or other. To classify providers, we linked National Provider Identifiers (NPI) in the claims to the National Plan and Provider Enumeration System (NPES),¹⁶ which associates each provider with one or more self-identified taxonomy codes representing provider type and specialty and has at least comparable accuracy to other national physician databases.¹⁷

We focused on 9 specific medical subspecialties: cardiology, endocrinology, hematology, infectious disease, gastroenterology, nephrology, neurology, pulmonology, and rheumatology. We selected these medical subspecialties because they have separate pediatric and adult training pathways; they have distinct pediatric and adult NPES taxonomy codes; and they provide outpatient care. Visits to these subspecialists were categorized as either pediatric medical subspecialty visits or adult-trained medical subspecialty visits based on NPES taxonomy codes. Subspecialists with both pediatric and adult-trained subspecialty taxonomy codes were classified as pediatric subspecialists for this analysis.

All remaining visits were categorized as “other.” The majority of “other” visits were to generalist physicians (eg, general pediatricians, family practitioners), other physicians (e.g., surgeons, psychiatrists, specialist physicians not included in our 9 selected subspecialties), and non-physician providers (eg, psychologists, optometrists). Provider type was identified for 96% of visits, with 4% unidentified.

To validate use of NPES taxonomy to categorize visits, we compared our rates of subspecialty care with the 2011-2012 National Survey of Children's Health (NSCH)¹⁸ and 2010 Medical Expenditure Panel Survey (MEPS).^{19,20} For the most similar comparison, we examined the Pennsylvania Medicaid claims using a broader definition of specialty physician (adult and pediatric medical and surgical specialists) and one year of claims (2011), resulting in 20.4% of children having a specialty visit in 2011 in the Pennsylvania Medicaid claims. Subspecialty utilization was reported for 25.6% of publicly-insured children in Pennsylvania in the NSCH, and 16.2% of publicly-insured children nationally in MEPS, indicating that our results are within the range of other estimates, strengthening the validity of our approach.

To measure geographic access, we used travel time to closest pediatric referral center, because prior studies indicate that the majority of pediatric subspecialists practice in such settings^{21,22} and because of known imprecision in locating individual subspecialists.^{22,23} We identified pediatric referral centers in Pennsylvania using the listing of children's hospitals in the Children's Hospital Association directory.²⁴ We excluded hospitals that offered 2 or

fewer of the 9 identified pediatric subspecialties throughout the study period based on review of hospital information and Medicaid claims, thereby focusing on centers providing relevant outpatient pediatric subspecialty care during the study period. For each child, we determined travel time to pediatric referral center by calculating on-road travel time from the child's ZIP code centroid to the closest pediatric referral center using ArcGIS (ESRI, Redlands, CA). Because of potential imprecision in using ZIP code centroids, we categorized travel time into 30 minute intervals to focus on relative travel time rather than each additional minute of travel time. To assess the validity of travel time to pediatric referral center as a measure of geographic access to pediatric subspecialists, we mapped county-level pediatric medical subspecialist counts from the Health Resources and Services Administration Area Health Resource File²⁵ superimposed on identified referral center locations, allowing visualization of pediatric subspecialist supply relative to identified referral centers.

Using the claims we defined additional variables associated with subspecialty care in prior literature,^{5,13,26-32} in order to examine their association with pediatric versus adult-trained subspecialist use. Age was determined at the beginning of the observation period based on date of birth. Race/ethnicity and supplemental security income (SSI) eligibility were obtained from Medicaid enrollment files. Family income was estimated using ZIP code median household income from 2010 US census data categorized by 2012 federal poverty levels. Medicaid type was determined from Medicaid enrollment data and was categorized as managed care organization (MCO) versus fee-for-service (FFS) plan. We identified complex chronic conditions (CCCs) using a standard methodology^{33,34} designed to identify chronic diagnoses with sufficient severity to require pediatric subspecialty care. For example, identified respiratory CCCs include respiratory malformations, chronic respiratory disease, and cystic fibrosis, but do not include less complex chronic diagnoses such as asthma. CCCs span neuromuscular, cardiovascular, respiratory, renal, gastrointestinal, hematologic/immunologic/rheumatologic, metabolic, congenital, genetic, and malignant diagnoses.

Statistical analyses

We described the cohort with descriptive statistics. We examined the unadjusted association between travel time and (1) any medical subspecialist use and (2) adult- trained medical subspecialist use among children using medical subspecialists. We performed tests for trend using travel time category as a continuous variable in logistic regression models. We assumed *a priori* that the association between travel time and subspecialist use would vary by presence or absence of CCCs, and therefore stratified analyses by CCC status. To confirm this assumption, we tested for interaction between travel time and CCC status in a logistic regression model using the full cohort.

To examine adjusted associations between travel time and use of both pediatric and adult-trained subspecialists while also examining other patient characteristics, we performed multinomial logistic regression to model three potential outcomes for each child: (1) any adult-trained subspecialist visit, (2) only pediatric subspecialist visits (and no adult-trained subspecialty visits), and (3) no pediatric or adult-trained subspecialist visits. Adjusted

models included travel time, child age, sex, race/ethnicity, SSI eligibility, ZIP code income, and Medicaid type (managed care versus fee-for-service). Multinomial model output is reported as a relative risk ratio (RRR), which is interpreted as the effect of one unit change in the exposure on the relative risk of each outcome (i.e., adult-trained subspecialist visits or pediatric subspecialist visits) compared with the referent outcome (i.e., no subspecialist visits). We again stratified *a priori* by CCC status and tested the interaction assumption through an interaction term for travel time and CCC status in a full cohort multinomial model.

To understand how adult-trained subspecialist use varied by subspecialty, we conducted sub-analyses using separate multinomial logistic regressions for each subspecialty (e.g., any adult-trained cardiology visits; only pediatric cardiology visits; no pediatric or adult-trained cardiology visits) and qualitatively compared risk-estimates across subspecialty. For these models, we included children with and without CCCs to ensure an adequate number of cases, adjusting for CCC status in addition to variables noted above. To examine whether adult-trained subspecialist use, when considered along with pediatric subspecialty use, attenuated differences in overall subspecialty use for each subspecialty, we examined use of any subspecialist (adult-trained or pediatric) in each subspecialty through logistic regression models. Analyses were performed using Stata version 14 (StataCorp, College Station, TX).

Results

County-level pediatric subspecialty supply varied widely and correlated with pediatric referral center location (Figure 1; available at www.jpeds.com). Fifty-four counties (81%) contained 5 pediatric subspecialists, and only counties containing or adjacent to pediatric referral centers contained >50 pediatric subspecialists.

Of 1.1 million children, 45% of children had 30 minute travel time to a pediatric referral center, and 14% had >90 minute travel time (Table I). CCCs were identified for 195,096 children (17%) and were roughly equally distributed across travel time categories. In contrast, racial/ethnic composition varied by travel time.

Any medical subspecialty care

In unadjusted results, 8.0% (90,318) of children had at least one outpatient visit over 24 months with either a pediatric or adult-trained subspecialist in one of the specified medical subspecialties, including 9.0% of children with 30 minute travel time and 6.9% of children with >90 minute travel time ($p<0.001$). Increased travel time was associated with decreased subspecialist use for children with and without CCCs (Figure 2, A). Among children without CCCs, 4.4% with >90 minute travel time used subspecialists compared with 5.9% of children with 30 minute travel time ($p<0.001$). Among children with CCCs, 20.1% with >90 minutes travel time used subspecialists compared with 23.2% with 30 minute travel time ($p<0.001$). The interaction term between CCCs and travel time in a logistic model was statistically significant ($p<0.001$), and indicated that compared with children with CCCs, children without CCCs experienced a larger decrease in subspecialty use with increasing travel time.

Adult-trained medical subspecialty care among children using medical subspecialists

Among children who received medical subspecialty care, 10.4% received that care from adult-trained subspecialists, including 18.2% of children with >90 minute travel time and 6.6% of children with ≤30 minute travel time ($p<0.001$). Increased travel time was associated with increased adult-trained subspecialist use for children with and without CCCs (Figure 2, B). Among children without CCCs, 20.4% with >90 minute travel time used adult-trained subspecialists compared with 7.7% of children with ≤30 minute travel time ($p<0.001$). Among children with CCCs, 15.7% with >90 minute travel time used adult-trained subspecialists compared with 5.3% with ≤30 minute travel time ($p<0.001$). The interaction term between CCCs and travel time in a logistic model was statistically significant ($p=0.007$), and indicated that compared with children without CCCs, the association between increased travel time and increased adult-trained subspecialist use was larger for children with CCCs.

Adjusted association between travel time and subspecialist use

In adjusted multinomial analysis, increased travel time to pediatric referral center was associated with greater likelihood of adult-trained subspecialist use and decreased likelihood of pediatric subspecialist use (Table II). Compared with children with ≤30 minute travel time, children with >90 minute travel time were less likely to use pediatric subspecialists (without CCCs: RRR 0.66, 95%CI 0.63-0.68; with CCCs: RRR 0.76, 95%CI 0.73-0.79) and more likely to use adult-trained subspecialists (without CCCs: RRR 1.94, 95%CI 1.79-2.11; with CCCs: RRR 2.33, 95%CI 2.10-2.59). The interaction term between CCCs and travel time in a multinomial model was statistically significant ($p<0.001$), and indicated that compared with children without CCCs, increasing travel time among children with CCCs was associated with a smaller decrease in pediatric subspecialist use and a larger increase in adult-trained subspecialist use.

Other patient characteristics associated with subspecialty use

In addition to travel time, additional factors were associated with use of adult-trained versus pediatric subspecialists (Table II). For example, among children without CCCs, greater likelihood of adult-trained subspecialist use was associated with older age (12-16 year olds: RRR 3.16, 95%CI 2.91-3.43), minority race (non-Hispanic black race: RRR 1.17, 95%CI 1.09-1.26), lower neighborhood income (100-199% federal poverty level: RRR 1.26, 95%CI 1.11-1.43), and managed care plan enrollment (RRR 1.22, 95%CI 1.15-1.29) compared with reference groups. These variables were also associated with decreased pediatric subspecialist use. Among children with CCCs, older age and minority race/ethnicity were associated with increased adult-trained subspecialist use.

Sub-analyses by subspecialty

The impact of travel time on use of pediatric and adult-trained subspecialists varied qualitatively by subspecialty. For all examined subspecialties except cardiology, pediatric subspecialist use was significantly decreased for children with >90 minute compared with ≤30 minute travel time (Figure 3, A). For most but not all examined subspecialties, adult-trained subspecialist use was significantly increased for children with >90 minute compared

with 30 minute travel time (Figure 3, B). When considering use of either adult-trained subspecialists and pediatric subspecialists (“any subspecialist”) (Figure 3, C), children with >90 minute travel time did not differ significantly in use of cardiologists, neurologists, or pulmonologists compared with 30 minute travel time, but still had decreased use of other subspecialties.

Discussion

In state-wide analysis of over 1 million children, 10% of children who received medical subspecialty care were cared for by adult-trained medical subspecialists. Among children who lived more than 90 minutes from pediatric referral centers, the proportion receiving their subspecialty care from adult-trained subspecialists was over 18%. Although the magnitude of the effect differed, increased travel time was associated with increased adult-trained subspecialist use for both children with CCCs as well as children without CCCs. Adult-trained subspecialty utilization also varied by race and neighborhood income. Altogether, these findings suggest that geographic and socioeconomic barriers are associated with use of adult-trained medical subspecialists in place of pediatric medical subspecialists.

The American Academy of Pediatrics recommends that children receive care from pediatric-trained physicians.¹ Underlying this recommendation is the premise that pediatric physicians provide superior care for children. This premise is supported by evidence in surgical specialties^{12,35} particularly for children with more complex conditions and comorbidities. In medical fields, the data regarding use of adult-trained subspecialists by children are limited,³⁵ with our results addressing this knowledge gap by quantifying the volume of care provided to children by adult-trained medical subspecialists. To understand the implications of this practice, further work is needed to compare outcomes for adult-trained versus pediatric subspecialists in medical fields, recognizing that findings will likely vary by condition and comorbidities. For circumstances where pediatric-trained subspecialist outcomes are found to be superior, receipt of pediatric subspecialty care could then be incentivized through quality measures or other means. For conditions where adult-trained and pediatric subspecialists have equivalent outcomes, strategies to incorporate targeted use of adult-trained subspecialists could help improve access to care for children, particularly in the context of pediatric subspecialist shortages. Recent surgical guidelines provide a precedent for specifying which patients and conditions require pediatric-specific care.¹² A similar approach to pediatric medical subspecialty care may allow more appropriate triaging of patients based on medical needs rather than the current *de facto* triaging based on geographic and socioeconomic barriers.

Although we identified that children living at distance to pediatric referral centers had increased use of adult subspecialists, these children were still less likely to receive subspecialty care overall – even after considering use of both pediatric and adult-trained subspecialists. As strategies to address disparities in access to subspecialty care are implemented, further study of their impact is needed. One such strategy is subspecialty telemedicine, which offers the potential for virtual encounters between patients and subspecialists across geographic distances,³⁶ although expansion of telemedicine will require additional infrastructure, adequate human resources, and changes in reimbursement

models in order to truly increase access to care.³⁷ Telemedicine was not covered by Pennsylvania Medicaid until the end of the study period, so the current study could not investigate telemedicine's impact on geographic disparities in subspecialist use by children.

Another strategy that may improve access to subspecialty care for children is to increase the pediatric subspecialist supply through expansion of pediatric-focused graduate medical education and policies to encourage medical graduates to enter pediatric subspecialties.^{1,4} Increased supply of pediatric subspecialists has not historically improved the geographic distribution of pediatric subspecialists,³⁸ but increased supply paired with increased use of telemedicine may reduce geographic access disparities.

In addition to strategies that increase the delivery of subspecialty care directly to patients, additional strategies aim to improve access to subspecialty care by providing subspecialist support to primary care providers. Such strategies include referral guidelines,³⁹ telephone consultation,⁴⁰ e-consultations,⁴¹ and telemedicine-based mentoring and co-management.⁴² These programs aim to reduce unmet demand for subspecialist visits by supporting care in the community. In addition to primary care providers, adult-trained subspecialists caring for children may also benefit from the support of pediatric subspecialists through these strategies.

There may also be opportunities to learn from specific subspecialties in order to identify additional strategies to reduce geographic disparities in subspecialty care use. We found that subspecialist use varied by travel time for many subspecialties, but not for others (such as pediatric cardiology). Thus further examination using different data sources may identify additional factors (such as use of satellite/outreach clinics, use of supervised physician assistants and nurse practitioners within specialty clinics,⁴³ variation in scheduling practices) that reduce access disparities for children needing subspecialty care.

Finally, evidence-based guidelines to inform the use of pediatric versus adult-trained subspecialists, as have been developed in the surgical fields,¹² may ultimately be an additional strategy to help improve access to medical subspecialty care for children, although the impact of the surgical guidelines on child health outcomes is not yet known. As discussed above, further research is needed before such guidelines can be developed in medical fields, but our work quantifies the degree to which adult-trained medical subspecialists are actively caring for children, thereby supporting the value of further investigation into when this practice is most appropriate.

Our analysis has several limitations. First, our analysis included only Medicaid beneficiaries. However, Medicaid is the largest single payer in Pennsylvania, providing data on over 1 million children with similar financial access distributed over a geographically diverse area, resulting in an optimal setting for studying the impact of geography. Medicaid analysis is also particularly relevant for government payers seeking to improve access within their networks. Second, our analysis focused on a single state. Pennsylvania has a relatively high proportion of residents living in rural counties (27%) but also ranks 10th nationally in number of pediatric subspecialists after adjusting for child population,²⁵ both of which may impact the magnitude of care by adult-trained subspecialists in Pennsylvania relative to other

states. However, as the sixth most populous state, Pennsylvania also has substantial racial and economic diversity, and multiple pediatric referral centers across the state, which improve generalizability to the US. Third, we measured travel time to pediatric referral centers and did not account for location of satellite/outreach clinics or subspecialists practicing outside of the identified pediatric referral centers. However, misclassification of some patients who live at distance to identified referral centers but close to satellite clinics or private practice subspecialists would result in underestimation rather than overestimation of the impact of travel time, which only strengthens our conclusions. Fourth, our primary dependent variable was any subspecialist use, and we did not examine follow-up intervals, quality of care, or health outcomes, which are potential avenues for future research. Relatedly, the “appropriate” volume of subspecialty care for children with and without CCCs is unknown,⁴⁴ such that we could not assess whether children received the necessary amount of care, and focused instead on unexplained variation. Fifth, we acknowledge that there may be residual confounding in our models. Sixth, prior work identified cases in another data source where adult subspecialists were erroneously classified as pediatric subspecialists.⁴⁵ Even though we suspect greater accuracy in the NPPEs due to NPI use in clinical practice, we note that if the same misclassification bias exists in the NPPEs, our analysis will underestimate the proportion of care provided to children by adult-trained subspecialists. Finally, we purposefully examined 9 medical subspecialties with both pediatric and adult subspecialists, and did not examine surgeons, psychiatrists, or medical fields lacking pediatric-specific specialists. Examining these fields may yield larger estimates of non-pediatric physicians caring for children, but our intent was to understand the use of adult subspecialists in medical fields where pediatric subspecialists exist.

Adult-trained medical subspecialists provide care to 1 in 10 children seeking subspecialty care overall, and to 1 in 6 children with >90 minute travel time to pediatric referral centers. In addition to travel time, disparities in pediatric and adult-trained subspecialist use are associated with race and neighborhood income. Understanding the volume and consequences of children receiving care from adult-trained medical subspecialists may allow providers, healthcare systems, and policy makers to more appropriately align the subspecialty workforce with the needs of the pediatric population.

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Abbreviations

RRR	relative risk ratio
CI	confidence interval
CCC	complex chronic conditions
NPI	National Provider Identifier
NPES	National Plan and Provider Enumeration System
NSCH	National Survey of Children's Health
SSI	supplemental security income
MCO	managed care organization
FFS	fee-for-service

Figure 1.

online: Location of identified pediatric referral centers (open circles) and number of pediatric subspecialists per county (from the 2011-2012 Area Health Resource File).

a: Percent of children receiving any medical subspecialty care over 24 months

b: Among children receiving subspecialty care, percent receiving care from adult-trained subspecialists

Figure 2. Unadjusted use of subspecialists by travel time

Abbreviation: CCC=complex chronic conditions

Figure 3.

Adjusted relative risk ratios for (A) pediatric subspecialty use and (B) adult-trained subspecialist use and (C) adjusted ORs for any subspecialty use over 24 months time for children living >90 minutes from pediatric referral centers compared with children living within 30 minutes of pediatric referral centers. Models are adjusted for child age, race, sex, SSI eligibility, ZIP code median income, Medicaid plan type, and presence of complex chronic conditions.

Table 1
Demographics of study cohort stratified by travel time to pediatric referral center

	All children	Children Stratified by Travel Time to Pediatric Referral Center (minutes)			
		0-30 min	31-60 min	61-90 min	>90 min
	n=1,126,573	n=508,484 (45%)	n=261,984 (23%)	n=196,788 (17%)	n=159,317 (14%)
Age					
0 to 1 years old	318,249 (28%)	147,167 (29%)	73,622 (28%)	54,179 (27%)	43,281 (27%)
1 to 6 years old	207,060 (27%)	137,260 (27%)	72,632 (28%)	53,943 (27%)	43,233 (27%)
6 to 12 years old	302,652 (27%)	132,982 (26%)	71,143 (27%)	54,132 (28%)	44,395 (28%)
12 to 16 years old	198,612 (18%)	91,075 (18%)	44,585 (17%)	34,534 (18%)	28,418 (18%)
Sex					
Female	539,377 (48%)	245,023 (48%)	123,904 (47%)	94,476 (48%)	75,974 (48%)
Male	587,196 (52%)	263,461 (52%)	138,080 (53%)	102,312 (52%)	83,343 (52%)
Race					
Non-Hispanic Black	308,224 (27%)	249,233 (49%)	30,419 (12%)	17,478 (9%)	11,094 (7%)
Hispanic	158,253 (14%)	67,898 (14%)	38,602 (15%)	45,509 (23%)	6,244 (4%)
Asian	24,507 (2%)	18,470 (4%)	3,421 (1%)	1,604 (1%)	1,012 (1%)
Non-Hispanic White	596,107 (53%)	150,748 (30%)	180,540 (69%)	126,516 (64%)	138,303 (87%)
Other	39,482 (4%)	22,135 (4%)	9,002 (3%)	5,681 (3%)	2,664 (2%)
Medicaid enrollment category					
Income-based eligibility	1,006,743 (89%)	460,676 (91%)	227,272 (87%)	176,872 (90%)	141,923 (89%)
SSI eligibility	119,830 (11%)	47,808 (9%)	34,712 (13%)	19,916 (10%)	17,394 (11%)
ZIP Code Median Income ^d					
0-99% FPL	77,495 (7%)	61,736 (12%)	5,745 (2%)	2,488 (1%)	7,526 (5%)
100-199% FPL	606,944 (53%)	291,495 (57%)	94,195 (36%)	118,670 (60%)	102,584 (64%)
200-299% FPL	360,712 (32%)	120,116 (24%)	125,321 (48%)	66,864 (34%)	48,411 (30%)
300% FPL	77,780 (7%)	34,669 (7%)	35,272 (13%)	7,545 (4%)	294 (0.2%)
Not identified	3,642 (0.3%)	468 (0.1%)	1,451 (0.6%)	1,221 (0.6%)	502 (0.3%)

	All children	Children Stratified by Travel Time to Pediatric Referral Center (minutes)			
		0-30 min	31-60 min	61-90 min	>90 min
	n=1,126,573	n=508,484 (45%)	n=261,984 (23%)	n=196,788 (17%)	n=159,317 (14%)
Medicaid Plan Type					
Managed Care Organization	791,736 (70%)	371,821 (73%)	174,466 (67%)	132,972 (68%)	112,477 (71%)
Fee For Service	334,837 (30%)	136,663 (27%)	87,518 (33%)	63,816 (32%)	46,840 (29%)
Complex Chronic Conditions ^b					
No complex chronic conditions	931,477 (83%)	415,514 (82%)	218,759 (84%)	163,904 (83%)	133,300 (84%)
1 complex chronic condition	195,096 (17%)	92,970 (18%)	43,225 (17%)	32,884 (17%)	26,017 (16%)

Abbreviations: FPL=federal poverty level. SSI=supplemental security income.

^aZIP code median income reported as % of FPL for a family of 4 in 2012.

^bComplex chronic conditions, identified using previously published algorithm.^{30,31}

Table 2

Adjusted RRRs for use of adult versus pediatric subspecialists

	Children without CCCs			Children with CCCs		
	Any Adult-Trained Subspecialty Visit	Only Pediatric Subspecialty Visit	RRR (95% CI)	Any Adult-Trained Subspecialty Visit	Only Pediatric Subspecialty Visit	RRR (95% CI)
Travel time to pediatric referral center						
30 minutes	Ref	Ref		Ref	Ref	
31-60 minutes	1.23 (1.13-1.33) [*]	0.64 (0.62-0.66) [*]		1.64 (1.49-1.81) [*]	0.81 (0.79-0.84) [*]	
61-90 minutes	1.88 (1.74-2.04) [*]	0.75 (0.72-0.77) [*]		1.83 (1.66-2.03) [*]	0.87 (0.84-0.90) [*]	
>90 minutes	1.94 (1.79-2.11)	0.66 (0.63-0.68) [*]		2.33 (2.10-2.59) [*]	0.76 (0.73-0.79) [*]	
Age						
0 to 1 years old	Ref	Ref		Ref	Ref	
1 to 6 years old	1.28 (1.18-1.40) [*]	0.48 (0.47-0.49) [*]		1.24 (1.10-1.40) [*]	0.59 (0.57-0.61) [*]	
6 to 12 years old	1.56 (1.44-1.70) [*]	0.42 (0.41-0.43) [*]		1.45 (1.30-1.61) [*]	0.43 (0.41-0.44) [*]	
12 to 16 years old	3.16 (2.91-3.43) [*]	0.37 (0.35-0.38) [*]		2.94 (2.65-3.24) [*]	0.36 (0.35-0.37) [*]	
Sex						
Female	Ref	Ref		Ref	Ref	
Male	0.83 (0.79-0.88) [*]	1.04 (1.02-1.06) [*]		0.90 (0.84-0.96) [*]	1.02 (1.00-1.04)	
Race						
Non-Hispanic Black	1.17 (1.09-1.26) [*]	0.96 (0.94-0.99) [*]		1.00 (0.90-1.10)	1.04 (1.01-1.08) [*]	
Hispanic	0.80 (0.73-0.87) [*]	1.09 (1.06-1.13) [*]		0.87 (0.78-0.97) [*]	1.15 (1.11-1.20) [*]	
Asian	0.73 (0.58-0.93) [*]	0.90 (0.83-0.96) [*]		1.06 (0.80-1.41)	1.14 (1.05-1.24) [*]	
Non-Hispanic White	Ref	Ref		Ref	Ref	
Other	0.83 (0.70-0.99) [*]	1.05 (1.00-1.11)		1.05 (0.87-1.26)	1.09 (1.03-1.15) [*]	
Medicaid enrollment category						
Income-based eligibility	Ref	Ref		Ref	Ref	

	Children without CCCs		Children with CCCs	
	Any Adult-Trained Subspecialty Visit	Only Pediatric Subspecialty Visit	Any Adult-Trained Subspecialty Visit	Only Pediatric Subspecialty Visit
SSI eligibility	1.68 (1.55-1.81) *	2.13 (2.06-2.21) *	1.56 (1.45-1.68) *	2.23 (2.16-2.29) *
	RRR (95% CI)		RRR (95% CI)	
ZIP Code Median Income ^b				
0-99% Federal Poverty Level	1.10 (0.93-1.32)	1.29 (0.80-1.16)	0.91 (0.75-1.11)	0.90 (0.85-0.95) *
100-199% Federal Poverty Level	1.26 (1.11-1.43) *	0.90 (0.86-0.93) *	0.97 (0.84-1.11)	0.81 (0.77-0.84) *
200-299% Federal Poverty level	1.39 (1.22-1.58) *	0.81 (0.78-0.84) *	1.15 (1.00-1.32)	0.87 (0.83-0.91) *
300% Federal Poverty Level	Ref	Ref	Ref	Ref
Not identified	0.47 (0.23-0.96) *	0.96 (0.80-1.16)	1.62 (1.04-2.51) *	0.93 (0.67-1.02) *
Medicaid Plan Type				
Managed Care Organization	1.22 (1.15-1.29) *	0.97 (0.95-0.99) *	1.02 (0.95-1.11)	0.81 (0.79-0.83) *
Fee For Service	Ref	Ref	Ref	Ref

Abbreviations: CCC= complex chronic condition. RRR=relative risk ratio; CI=confidence interval.

* =p<0.05.

Adjusted RRRs for any adult-trained subspecialty use and any pediatric subspecialty use over 24 months, adjusted for all listed variables and stratified by presence or absence of complex chronic conditions (CCCs).