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RESEARCH ARTICLE

Insurance-Correlated Disparities in Pediatric Allergy Diagnosis

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ABSTRACT: The conditions of asthma, atopic dermatitis, and allergic rhinitis are some of the most prominent chronic illnesses that plague children with food allergies in the United States. Getting a timely diagnosis is instrumental to managing these illnesses, but disparities in healthcare access, particularly between Medicaid and non-Medicaid (privately insured) patients, pose obstacles. This study will determine whether a patient's age of diagnosis differs based on their insurance status. Analyzing over 330,000 cases in a healthcare diagnosis dataset, these findings identified statistically significant differences in diagnosis for asthma, allergic rhinitis, and atopic dermatitis among Medicaid-insured children vs. privately-insured children. While food allergy diagnosis showed similarities across groups, my findings and further research showed inequality in allergy symptoms. This study concluded that insurance status is significant: while Medicaid children are diagnosed earlier, they still face worse long-term outcomes. These findings demonstrate the need for policy interventions with the goal of improving access to pediatricians/immunologists and focusing on timely, quality care for all patients. Future research should evaluate the long-term effects of Medicaid vs. privately insured healthcare.

KEYWORDS: Medical and Health Sciences, Immunology, Pediatric Allergy, Medicaid Disparities, Diagnosis Timing.

Introduction

Allergies are increasingly recognized as a major health and economic burden in the United States. Food allergies affect approximately 5%–6% of young children and around 3.7% of adults, becoming increasingly prevalent over time.[1] In some Western countries, and particularly among infants, these percentages can climb as high as 10%.[2] Treating food allergies costs families and the healthcare system an estimated $24.8 billion annually, showing its vast financial impact.[1] The most common allergens include milk, eggs, soy, wheat, peanuts, and tree nuts, together accounting for the majority of reactions in children, while adults more frequently react to crustaceans, tree nuts, peanuts, or fish.[3]

Medicaid is the largest public insurance program for low-income children in the United States, covering upwards of 40% of children.[4] It matters for these low-income children as it provides access to allergists and life-saving emergency medication such as epinephrine. Essentially, it is intended to reduce financial barriers to healthcare. However, patients covered under Medicaid frequently encounter healthcare provider shortages, longer wait times, and limited access to any sort of specialists, which delays diagnosis and management of their allergic diseases.[5] In contrast, privately-insured children often benefit from greater provider availability, shorter wait times, and easy access to specialty care.[5] The allergic conditions are also very costly, with Medicaid-insured children contributing significantly to rising pediatric expenses.[6] There is no shortage of conditions associated with food allergies, either.

The allergic conditions of asthma, atopic dermatitis, and allergic rhinitis are the most common and chronic illnesses affecting U.S. children with food allergies. Atopic dermatitis is a chronic skin condition also known as eczema and may be caused by the immune system responding to allergens,[7] Allergic rhinitis, or hay fever, takes place in the nasal ducts,[8] and asthma refers to inflammation in the lungs.[9] In fact, asthma alone impacts over six million individuals nationwide,[10] making it a very important illness to address. Medicaid-insured patients experience a higher degree of severe allergic reactions, such as anaphylaxis, because of barriers like reduced access to epinephrine.[5] These Medicaid patients are more likely to rely on emergency room care rather than preventive treatment, leading to glaringly worse health outcomes.[11] This reliance on emergency care instead of active management may indicate a challenge faced by Medicaid-enrolled children in the process of receiving effective allergy care.[12] Recent epidemiological work has shown that food allergy prevalence peaks during early childhood, the reason for divergence possibly being socioeconomic factors like insurance status.[13]

Broad trends further deepen this issue: data from the UK Clinical Practice Research Datalink reveal an uptick in occurrences of pediatric food allergy.[14] These trends show serious negative consequences for allergy care; early action can drastically impact disease progression. National guidelines for the management of food allergy show the importance of early recognition and effective management.[15] Diagnosis delays often postpone important treatment interventions (immunotherapy, epinephrine prescription) and could contribute to allergic symptom longevity and severity over a longer period of time.

Prior studies have also demonstrated gaps in the use of guideline-recommended therapies among Medicaid-enrolled children with allergic rhinitis and asthma, including lower rates of allergy immunotherapy and other preventive care measures.[16] These discrepancies in care demonstrate structural barriers within the Medicaid system and justify the need for

DOI: 10.36838/IJHSR89.278

data analysis in allergies. However, a major gap in the research is that most studies focus on what happens after a child is diagnosed, such as differences in treatment, follow-up care, or emergency room use, while giving much less attention to whether insurance status affects when these conditions are first identified. This timing matters because early diagnosis shapes everything that comes next, from receiving preventive care to accessing specialists, yet it remains an underexamined part of pediatric allergy disparities.

Methodology

Data Access

This study analyzed a pediatric dataset containing 333,200 subjects with key details (data was downloaded from https://zenodo.org/records/4452917),[17] most importantly, diagnosis ages for various allergic and atopic conditions. One key variable was the patient's insurance status (PAYER_FACTOR), which indicated whether they were on Medicaid or not. Another important variable was the age at which a specific condition was diagnosed (e.g., ASTHMA_START, PEANUT_ALG_START, ATOPIC_DERM_START), which could either be an allergy or a symptom. Additional demographic factors included race, gender, and ethnicity. The dataset also included whether the patient was part of an "atopic march cohort," which essentially determined if their allergies were tracked from infancy to adolescence.[18]

T-tests and Wilcoxon Verification:

This study used the Welch two-sample t-test, which compares the means of two independent groups (in this case, Medicaid vs. non-Medicaid patients) even when there isn't equal variance or sample size.[19] This method was selected because the dataset had disparities in both sample size and variance between insurance categories. For example, in asthma-related data, the Medicaid group included nearly twice as many patients as the non-Medicaid group, which would invalidate other statistical tests.[20] Some may argue that another dataset should be used because of this issue, but this study found that these imbalances are very indicative of real-world differences in healthcare access.[21]

The Welch test provides more accurate and reliable p-values when dealing with unequal group sizes.[21] This reduces the risk of false positive/negative errors and strengthens the findings.[22] It is a widely recommended method in health outcomes research.[22] Because age-at-diagnosis data are often non-normally distributed, the results were verified using the Wilcoxon rank-sum test (Mann–Whitney U test),[23] a non-parametric alternative that is suitable for data like that.[24]

Regression:

This study used regression analysis to determine whether insurance status remained a significant predictor of diagnosis timing after controlling for confounders. In the regression model, the dataset was first filtered to remove implausible negative diagnosis ages, excluding 18 records across allergic rhinitis and atopic dermatitis because they had negative values (which were irrelevant to the data). Analyses were conducted using R, a platform known for being a great tool to manage clinical datasets.[25] The cleaned dataset was then used for regression modeling. Ethnicity-adjusted linear regressions were further expanded to include race and gender as covariates to better account for demographic confounding effects. For each allergic condition (asthma, allergic rhinitis, and atopic dermatitis), diagnosis age was modeled as a function of insurance status (Medicaid vs. non-Medicaid), ethnicity (Hispanic vs. non-Hispanic), race (Black, Asian or Pacific Islander, Other/Unknown), and gender (female vs. male). All coding, that being statistical analysis, visualization, and data cleaning, was performed in R, using functions such as t.test() for Welch two-sample comparisons,[26] wilcox.test() for Wilcoxon rank-sum verification,[24] and the ggplot2 package for graphical output.

Results and Discussion

Table 1 shows the demographic breakdown of race, gender, ethnicity, and insurance type.

Table 1: Demographic data for the dataset.

Variable	Category	Count	Percent
Race	White	183308	55
	Black	97795	29.4
	Asian or Pacific Islander	9152	2.7
	Unknown/Other	42945	12.9
Gender	Male	169032	50.7
	Female	164168	49.3
Ethnicity	Non-Hispanic	317868	95.4
	Hispanic	15332	4.6
Insurance	Non-Medicaid	246340	73.9
	Medicaid	86860	26.1

The first analysis used the aforementioned Welch's two-sample t-tests to compare age at diagnosis between Medicaid and non-Medicaid patients. As shown in Figure 1, Medicaid patients were diagnosed earlier across all three conditions. Benjamini-Hochberg adjusted p-values were used to account for false positives as well, indicated in the rightmost column. Table 2 summarizes the Welch two-sample t-test results for asthma, allergic rhinitis, and atopic dermatitis.

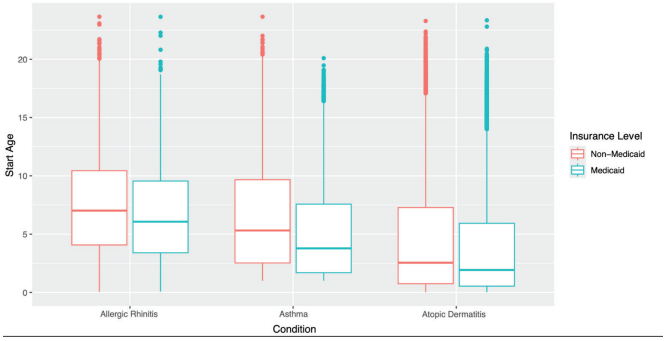


Figure 1: Welch two-sample t-test visualized in a box plot to show mean difference and spread. Non-Medicaid patients are consistently diagnosed earlier across all three symptoms of allergic rhinitis, asthma, and atopic dermatitis.

Table 2: Welch two-sample t-test for allergic conditions. The adjusted p-value indicates that the differences in age at diagnosis are unlikely to be due to chance alone, even after accounting for false discovery.

Condition	Mean Medicaid	Mean Non-Medicaid	P-Value	Adjusted P-Value
Asthma	5.11	6.39	$2.86e^{-277}$	$1.04e^{-48}$
Allergic Rhinitis	6.75	7.48	$7.07e^{-80}$	$2.34e^{-13}$
Atopic Dermatitis	3.82	4.54	$3.83e^{-63}$	$2.12e^{-13}$

These results were validated by the Wilcoxon rank-sum test (all $p < 1 \times 10^{-50}$), demonstrating that the findings held even when the data showed signs of deviancy. No statistically significant timing differences were observed for any tested food allergy (all adjusted p values > 0.65). So, for food allergy diagnoses, insurance level was not a prevailing factor, as the age at diagnosis did not differ significantly. As shown in Table 3, no food allergens displayed statistically significant differences after adjustment.

Table 3: The Welch two-sample t-test for allergens. Finds that age at diagnosis for specific food allergens does not differ significantly by insurance status. This is unlike that of the symptoms, as food allergen diagnoses appear to occur at comparable ages for Medicaid and non-Medicaid patients.

Allergy	Mean Medicaid	Mean Non-Medicaid	P-Value	Adjusted P-Value
Peanut	5.03	4.93	0.187	0.672
Egg	3.29	3.24	0.423	0.726
Milk	3.30	3.29	0.951	0.998
Wheat	4.55	4.54	0.949	0.998
Fish	6.63	6.90	0.146	0.657
Shellfish	8.72	8.81	0.443	0.726
Soy	3.96	4.09	0.349	0.699
Sesame	6.14	6.06	0.729	0.875
Walnut	7.60	7.33	0.319	0.699
Pecan	7.74	7.28	0.243	0.699
Pistachio	7.15	7.15	0.998	0.998
Almond	7.68	7.25	0.281	0.699
Hazelnut	7.88	7.68	0.641	0.875
Cashew	6.19	6.07	0.642	0.875

Because of uneven distributions within the data, comparison models were created to look for potential confounders. Within the data is an uneven distribution between race and insurance status. Running chi-square testing revealed associations between payer type and race ($p < 2.2 \times 10^{-16}$), with Medicaid patients more likely to be Black and less likely to be White. Figure 2 demonstrates the racial distribution differences across insurance categories.

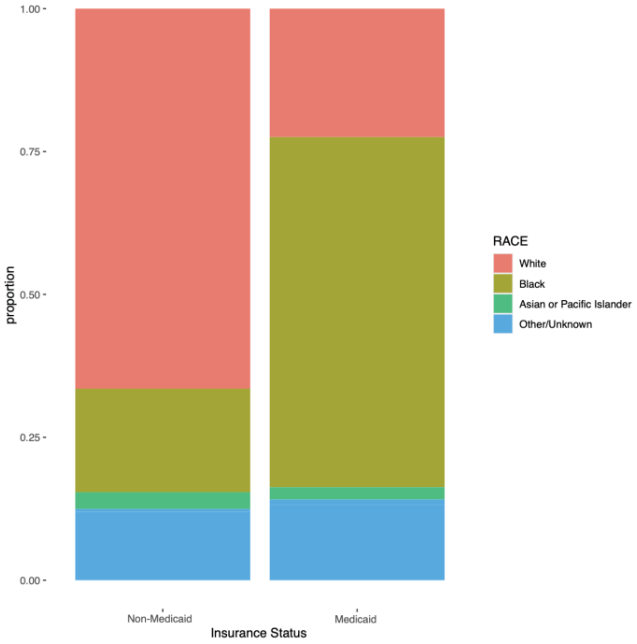
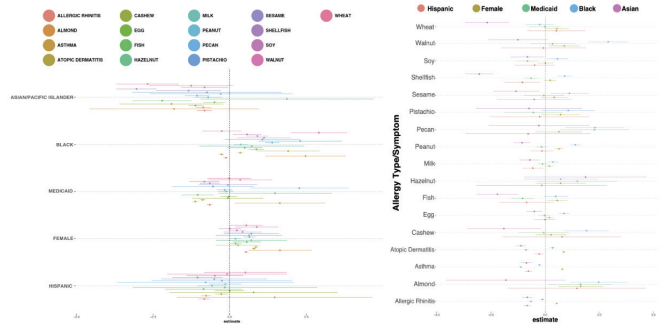


Figure 2: A proportional bar chart of race based on insurance. Due to the disparate race proportions, regression analysis is needed.

To isolate these effects and obtain a better picture of how insurance relates to diagnosis timing, I turned to regression analysis, which is shown in Figures 3a and 3b. It was used because it allows for estimating the independent effect of Medicaid coverage on diagnosis timing while holding other variables constant, thereby reducing bias from confounding factors. I ran multivariable linear regression models with age at diagnosis as the outcome variable, adjusting for race (Black, Asian, White), gender (male/female), and ethnicity (Hispanic or non-Hispanic).



(a) (b)

Figure 3a: Forests plot showing the independent effects of variables (race, gender, ethnicity, and Medicaid status) on outcome (age of diagnosis of allergies, conditions). Each point represents the regression estimate with 95% confidence intervals, where values left of zero indicate earlier diagnosis and values right of zero indicate later diagnosis.

Figure 3b: Forests pilot displaying the effect of variables on the same outcomes as Figure 3a. Estimates and 95% confidence intervals illustrate how different groups vary in timing of diagnosis for each allergy type.

DOI: 10.36838/IJHSR89.278

Figure 3a displays regression results for chronic allergic conditions, and Figure 3b shows results for individual food allergens. Medicaid coverage remained independently associated with earlier diagnosis for asthma, allergic rhinitis, and atopic dermatitis. Race and gender also showed independent effects (Figure 3a): Black children and female patients were often diagnosed later for multiple conditions, regardless of insurance. Small sample sizes in some specific allergies caused a wide confidence interval (Figure 3b).

The results from these tests and figures show significant differences in the timing of diagnosis for asthma, allergic rhinitis, and atopic dermatitis based on insurance level. In all three cases, children covered by Medicaid were diagnosed significantly earlier than non-Medicaid (e.g., asthma at 5.11 years vs. 6.39 years, $p < 1 \times 10^{-275}$), a result backed with Wilcoxon rank-sum verification ($p < 1 \times 10^{-250}$). The earlier diagnosis seen in Medicaid children likely reflects the point at which symptoms become severe enough to trigger emergency care rather than timely access to routine pediatric screenings. Because the dataset does not include visit type, interpretations about ER-driven diagnosis are drawn from patterns found in the literature rather than measured directly here. The results align with prior research indicating that Medicaid-insured children may have more frequent contact with primary care providers,[21] probably leading to earlier diagnosis during routine visits.

However, earlier diagnosis does not necessarily translate into better health outcomes. Within Medicaid populations specifically, food allergies are more prevalent than in privately insured groups and are linked to cost barriers, barring specialist access (like pediatricians) and consistency of care.[26] Prior studies suggest that Medicaid-insured children often experience barriers to specialist referral, fragmented follow-up care, and inconsistent access to advanced treatment modalities.[15] The results also align with evidence linking early-life risk factors, such as low birth weight, to higher asthma vulnerability, which is another thing that is prevalent in publicly insured children.[27] Public insurance is also linked to higher emergency department utilization, particularly for asthma,[28] indicating that early diagnoses would likely be from ER visits rather than doctor check-ups. Therefore, early diagnosis is a complex factor when judging these healthcare discrepancies.

Importantly, no statistically significant differences in diagnosis timing were observed for food allergies. As shown in Table 3, the mean diagnosis ages for each food allergen were nearly the same between Medicaid and non-Medicaid patients. This is consistent with literature indicating that food allergy diagnoses often occur following severe reactions, such as anaphylaxis, which prompt immediate medical attention (ER/hospital visits) regardless of insurance status.[11] While there was no food allergy diagnosis age difference, conditions like asthma and eczema are chronic; they need repeated care and access to specialists. For food allergens, estimates had wide confidence intervals and therefore showed no correlation based on the insurance factor. I therefore treat these allergen-specific findings as less relevant: the primary result is earlier diagnosis for asthma, allergic rhinitis, and atopic dermatitis, not food allergens as a group. Again, it shows how the type of disease and a person's insurance or income can combine to create glaring differences when children get diagnosed. Other studies have shown that delayed diagnosis can make chronic respiratory conditions more severe, harming patients.[29]

While there was no food allergy diagnosis age difference in Medicaid vs. non-Medicaid patients, the Medicaid bar is significantly affected after adjusting for race, sex, and ethnicity. This is most easily shown in the pecan, shellfish, pistachio, and soy regressions, showing Medicaid does become significant after adjusting for confounding factors. These findings demonstrate that insurance level is not the only thing affecting a patient's diagnosis, showing that this is a multifaceted issue that is affected by many factors. Taken together, these patterns show how complex diagnosis timing can be.

It should be noted that the only factor directly assessed in this analysis was the age of diagnosis. Other factors, like follow-up care and access to medication, were not explicitly indicated in the dataset and instead were determined based on research. Everything matters: younger asthma diagnosis correlates with lower remission rates into adulthood, but Medicaid's low quality of care likely makes this a non-solution.[30]

The regression analyses confirmed that Medicaid coverage is linked to earlier diagnosis for conditions like atopic dermatitis and asthma, even after adjusting for race, gender, and ethnicity. While the models accounted for key demographic factors, race and gender still showed independent associations with diagnosis timing, with black and female children generally diagnosed later. In sum, the study's findings reinforce that while Medicaid status predicts earlier diagnosis, it does not in any way lead to more specialized or effective care, making it a half-hearted solution to a serious health issue in children.

Overall, the consistent observation of earlier diagnosis among Medicaid patients, despite systemic barriers to care, indicates the complexity of pediatric allergy disparities. This study's findings support the need for targeted public health initiatives aimed at improving both early recognition and ongoing management of allergic disease in Medicaid populations. Potential policy solutions include improving specialist access, enhancing provider training, and addressing social factors that affect pediatric allergy care. The importance of early diagnosis is not unique to allergies. Even outside of allergy, parallels in early biomarker-driven sepsis research highlight the urgency of early identification, which shows that Medicaid's early diagnosis is still crucial, if flawed.[31]

Future research should examine how diagnosis timing is connected to health effects, such as emergency room visits, hospitalization rates, and long-term disease control. Tying diagnosis timing (and whether it stems from emergency care or routine screening) to healthcare outcomes can reveal how unequal access shapes treatment quality, helping systems improve care for children on Medicaid vs. those who are not.

■ Conclusion

The study of allergies is important due to its widespread nature among U.S. children and the associated symptoms. This study demonstrates that Medicaid-insured children are diagnosed with asthma, allergic rhinitis, and atopic dermati-

tis at significantly younger ages than their privately insured counterparts, a pattern that remains even after adjusting for race, gender, and ethnicity. With food allergies, there were no key differences in diagnosis timing, which may be explained by their detection likely happening after a reaction. While earlier diagnosis within the Medicaid population may appear favorable, it does not necessarily translate into better long-term outcomes, given persistent barriers to follow-up care, specialist access, and treatment continuity. Addressing these disparities will require a myriad of policy changes, including expanding access to specialists as well as improving both the quality and timeliness of care. One solution is to expand specialist access by increasing Medicaid reimbursement rates for allergists, which will likely improve provider participation and patient wait times. Future research should bridge these policies to healthcare outcomes, enabling a fuller understanding of how insurance status influences not just when, but how allergic diseases are managed in children as they grow into adulthood.

Acknowledgments

I would like to thank Matthew Montierth and Indigo Research for their guidance in this paper. I attest that the ideas, graphics, and writing in this paper are entirely my own.

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